FLAMINGOS at the KPNO 4-m

An Observer's Guide

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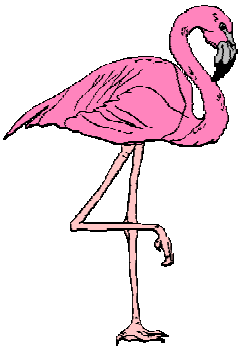

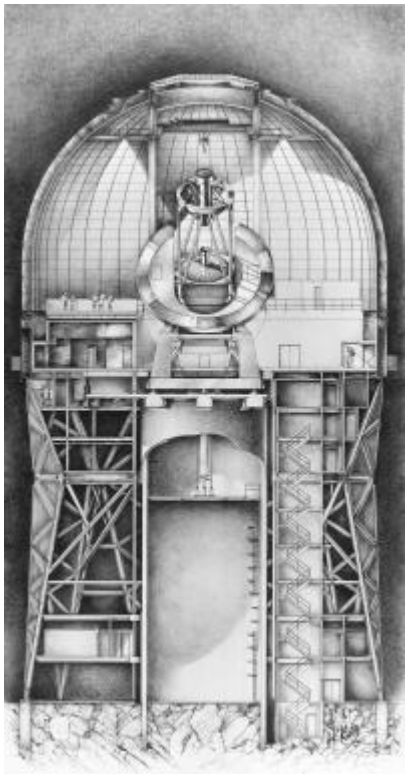

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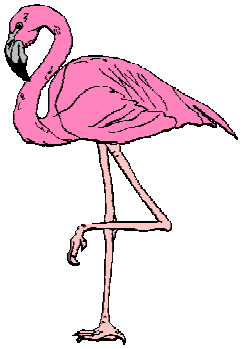

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I. FLAMINGOS + KPNO 4-m Overview

FLAMINGOS is the *FLoridA Multi-object Imaging Near-ir Grism Observational Spectrometer.* This manual provides the user with a good portion of the tools needed to successfully take data with FLAMINGOS at the KPNO 4-m telescope. A knowledge of basic unix commands is assumed.

FLAMINGOS is comprised of two cryogenic dewars. The MOS dewar, closest to the telescope backplane, contains a wheel which can position 11 slit plates in the Cassegrain focal plane. The Camera dewar, immediately following the MOS dewar contains all of the powered optics, filters, stops, grisms, and the detector array. A functional diagram showing the relative layout and connections to the various electronics is shown in Figure 1.

Array: Hawaii II 2048x2048 HgCdTe science grade array, divided into four quadrants with 8 amplifiers each (32 amplifiers for the whole array).

Linearity at 1.0V bias: 0.5% non-linear at 25,000 ADU
2% non-linear at 35,000 ADU
>3% non-linear at 40,000 ADU

Plate Scale and Field of View: 0.316"/pixel
10.8' FOV
Typical image quality (FWHM) = 2–3 pixels = 0.63" – 0.95".

Detector Characteristics:		
	Imaging	*Spectroscopy*
Bias Voltage (Volts)	1.0	0.75
Full Well (ADU)	~50,000	~38,000
Target Count level (ADU)	25,000 – 35,000	15,000 – 20,000
CDS Read Noise without Differential Amplifier (e)	~40	~40
Gain (e / ADU)	~4.9	~4.1

N.B. The default bias on boot of the MCE4 array controller is 0.776 V, which is not used in any observing configuration; the initialization script `initflam.pl` automatically sets the bias to 1.0 V for imaging, but queries the user if they wish to change the bias.

Filters: `J, H, K, Ks, JH` (*0.9 μm – 1.8 μm*), and `HK` (*1.25 μm – 2.5 μm*) bandpass filters.

Grisms: Two grisms are available, covering the `JH` (*0.9 μm – 1.8 μm*) and `HK` (*1.25 μm – 2.5 μm*) bandpasses. The `HK` grism may be used with the `HK` filter to obtain `H`– and `K`–band spectra in first order, or it may be used with the `JH` filter to obtain `H`-band in first order, and `J`-band in second order.

Long Slits: `2`, `3`, `6`, `9`, `12`, and `20`-pixel slits are available; the `3` and `6` pixel slits cover much of the chip but the others slits cover approximately two-thirds of the chip. All of these long slits are located on the MOS wheel. An extra `3`-pixel long slit is located in one of the 11 MOS positions.

Spectral Characteristics				
Filter / Grism Combination	*Band*	*R = λ / δλ (2 pix slit)*	*Dispersion (Å/pixel)*	*R = λ / δλ (3 pix slit)*
JH-bandpass + JH-grism	J	1400	4.68	960
	H	1800	4.68	1250
HK-bandpass + HK-grism	H	970	8.55	650
	K	1300	8.55	865
JH-bandpass + HK-grism	J (2^{nd} order)	1500	4.4	1000

MOS Plates: 11 positions are available for MOS plates; at present 1 position is occupied by a MOS plate shaped single long slit with width of 3 pixels; 3 pixel wide slits are customarily used at the 4-m telescope.

The masks cover approximately ±290 pixels of the chip in the dispersion direction.

The science grade array is offset in the spatial direction with respect to the MOS wheel field of view, which essentially means that the lower ~70 pixels of a MOS plate will not hit the detector. Lower in this case means the 70 pixels furthest *North* if the position angle (*PA*) is 0°, the 70 pixels furthest *East* if the *PA* is 90°, and the 70 pixels furthest *South* if the *PA* is 180°. See also *Appendix 4: Additional Notes on MOS plates.*

Position Angles: The position angle of the long slits and MOS plates matches that of the telescope instrument rotator. The allowed range is -0.6° to +180°. Small rotational offsets of the long slits and MOS plates are possible, and required, as the rotator positioning is too coarse for accurate slit positioning.

Mechanisms: The MOS dewar contains the Decker and MOS wheels; the Decker wheel contains an imaging hole, a psuedo dark, and aperture masks to baffle stray light before the MOS wheel. The Camera dewar contains the Filter, Lyot, and Grism wheels; the Lyot wheel contains Lyot stops for the KPNO 2.1-m and 4-m telescopes, and for the MMT; the Grism wheel contains the two grisms, two imaging apertures, *and the only truly dark cold stop in the system.*

Instrument Control: FLAMINGOS is operated via an ssh connection from *tan* to *flmn-4m-1a* (hereafter referred to as *flamingos1a*), which is the primary FLAMINGOS control computer. FLAMINGOS is set up so that all data taking is run from the command line of *flamingos1a* using a set of perl scripts[1]. *Flamingos1a* is mounted on the right-hand electronics rack with the instrument, in the Cassegrain cage. A second machine, *flamingos1b* (*flmn-4m-1b*) is in the rack as a backup data acquisition machine, and is generally turned off.

Data Acquisition & Storage: While you are taking data, all data will be located on *flamingos1a* in /data/4mguest/<UTDATE>/. If you type df -h, you can see how much of the 68 GB disk space is available; similarly if you type du -h, you can see how much disk space is used in the present directory (the

1 Located in /usr/local/flamingos/, in the directories perl_all_tel/, perl_kp4m/, flamingos.headers.lut/, and flamingos_modules/.

`-h` option is for *human readable* format, and it prints values out with `KB`, `MB`, and `GB` suffixes as appropriate).

Data Analysis: An `IRAF` session will be running on *flamingos1a*. Simple analysis tasks such as quick image arithmatic, image stacking, and image statistics can be performed with it while taking data. There are ***no*** pipeline reduction packages installed on *flamingos1a* for imaging or spectroscopy data. If you wish to reduce data simultaneously while taking data, we recommend that you transfer it to *nutmeg*, and do so there. However, if the night is shot by clouds, several non-distribution `IRAF` packages have been installed on *flamingos1a* (*e.g.* `xdimsum`) which may be useful . Let us know if you find any problems.

Data Display: FLAMINGOS images are automatically displayed in `ds9`, into frame buffers `1` and `2`, with odd images in buffer `1` and even images in buffer `2`. Other noteworthy points:

- `ds9` toggles the frame before loading the newest image, so you sometimes can briefly see the previous image in that buffer. You can choose to tile any of the buffers.
- The image name appears in the file name box in `ds9`; data values and pixel coordinates are also shown.
- `ds9` can read the rudimentary World Coordinate Information (WCS) in the FLAMINGOS header, and it displays the WCS compass arrows.
- `ds9` also has some very useful tools such as `rulers`. You should spend some time familiarizing yourself with `ds9` if you are mostly used to `ximtool`.
- No other display program is available for automatically displaying the images as they are taken.
- `IRAF` can load images into `ds9` with the `display` command, however, loading images directly into `ds9` (with the `File Open` buttons) is recommended, as it preserves the `ds9` ability to scale the images (using `IRAF display` suspends this ability).

Data Transport: Observers are responsible for removing their data from *flamingos1a* and transporting it to their home institution. All data will be removed from *flamingos1a* immediately after your observing run. The filesystem on *flamingos1a* is cross-mounted to the KPNO 4-m computer *nutmeg*, to which we recommend that you first move the data. This is easily done by running the script `Start.autocopy.4m.nutmeg.sh` (described in more detail in *§III. Nightly Startup Tasks*) on *flamingos1a*. Once the data are on *nutmeg*, you can write it to *nutmeg's* DDS4 tape drive or DVD writer. Alternatively, you can `ftp/scp` the data to your home institution or to your laptop; such data transport to your home institution may be quite slow, however (recently the transfer rate from *azure*, at the 2.1-m, to Florida was only ~220 KB/s). For taping, we recommend that you first `compress`, `gzip`, or `bzip` the data before writing it to tape with `tar`.

Image Size: Each FLAMINGOS frame is 16 MB in size! During a single night of imaging, it is possible to take 8 – 16 GB of data (500 to 1,000 images). Pay attention to disk usage, and bring many tapes and/or DVDs for data archiving.

Unix Tips: Many of the command names are quite long. However, if you type a portion of the command and then hit the `TAB` key, you will be offered a list of possible completions to the command name. Similarly, the up arrow key will allow you to go up through the history stack of commands entered on the command line. A familiarity with basic unix commands (*e.g ~, ls, cd, mkdir, rm, rmdir, cp, mv, history, df, du, ps, ctrl-c, ctrl-z, jobs, kill, grep, wc, tar, mt, ssh, scp, ftp* and *the up and down arrow keys*) is advised.

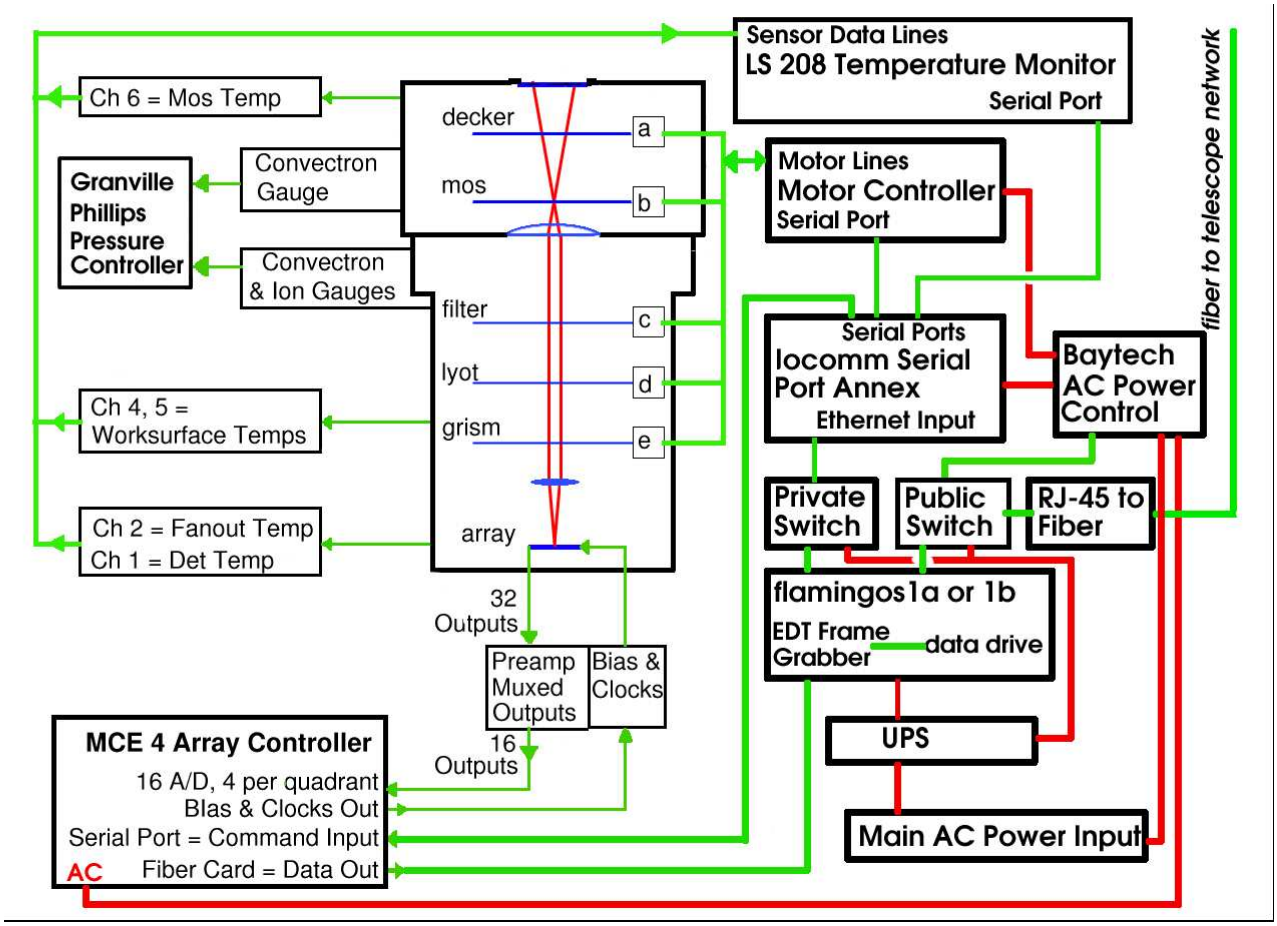


Figure 1. FLAMINGOS Functional Diagram. The relative layout and connnections between the various parts of FLAMINGOS are shown shematically. A schematic of the MOS and Camera dewars is shown in the middle of the figure, including the relative layout of the 5 internal mechanisms above the detector array, and the elements of the two electronics racks are shown on either side of the dewars, much as they are in actuality.

The input beam from the telescope is shown in red; it passes first through the Decker wheel (a baffle wheel) to the MOS wheel at the Cassegrain focus. The beam is collimated (some optical elements are not diagramed in this figure) before passing through the Filter, Lyot, and Grism wheels, and then through the camera optics to the detector array.

Biases and Clock voltages are input into the array by MCE4, the array controller. All 4 quadrants of the array are read out through all 32 output amplifiers; they are muxed down to 16 outputs at the preamp before they are sent into the 16 A/Ds on MCE4. The final output image is then sent via a fiber to the EDT frame grabber on the control computer *flamingos1a* or *1b*, where it is written to the data drive.

The observer makes a remote connection to *flamingos1a/1b* via the RJ-45 to fiber media converter at the instrument's public network switch. The Baytech networked AC power control module is accessible from *flamingos1a/1b* or a Kitt Peak machine, and the observer may toggle the power to MCE4, the Perle (formerly the Iocomm) serial port annex or the Motor controller.

Three software daemons running on *flamingos1a/1b* transfer commands via the private network switch to the Perle (which replaced the Iocomm), which passes the commands to the serial port of the correct device. The three devices are the MCE4 Array Controller, the Motor Controller, and the LS208 Temperature Monitor.

Halting A Script: Never type **`Ctrl-C`**. It is much safer to suspend a job with **`Ctrl-Z`**. Then you can kill the script by typing `jobs`, and `kill -9 %<job number>`. If you are moving a wheel, please just wait for the wheel to finish motion, and the script to complete, and then try again. If you are taking an image or a sequence of images, wait until the script starts counting the number of seconds elapsed in the exposure before suspending the script. Then run `ufstop.pl -clean -stop`, and start over. Never type `Ctrl-C` before the exposure time counter has begun.

Imaging Sensitivity

FWHM = 3 pixels = 0.95 arcseconds
Aperture = 2.2 arcseconds diameter

Band	*e/s for mag = 15*	*sky*		*10 σ limiting magnitude*		
		mag arcsec^{-2}	*e sec^{-1} pixel^{-1}*	*60 seconds*	*600 seconds*	*3600 seconds*
J	3450	15.7	180	18.8	20.0	21.0
H	4480	13.9	1250	18.0	19.2	20.2
K	4360	12.9	3050	17.5	18.7	19.7
K_s	3800	13.1	2210	17.6	18.8	19.75

These data are from the KPNO FLAMINGOS web site, www.kpno.noao.edu/manuals/flmn.

The above data were for the original J, H, and K_s filters, which were loaned to UF from NOAO and Gemini. New J, H, and K_s filters were installed during the summer of 2003. The signal levels with the new filters are similar to those in the table.

II.Starting FLAMINGOS

When you arrive at the 4-m telescope, you may have to bring up the FLAMINGOS windows and initialize the system (it should have been done during the checkout night). Steps 1–6 of this procedure will hopefully only need to be done once at the beginning of your run; however, you may need to repeat this process during the course of your observing time if you get logged out, or if the system crashes.

The observer interface is from the *tan* console. There are three monitors, labeled (from left to right) 0.1, 0.0, and 0.2. The setup procedure described below will utilize the center monitor for overall login and image display, the lefthand monitor for FLAMINGOS control, and the righthand monitor for IRAF tasks.

The full startup procedure follows:

1. Log on to ***tan***. The login is `4meter`; the password _____(taped to the edge of the monitor).

2. Once the desktop has come up:
   - Quit out of any automatically started windows.
   - On the middle monitor (*tan:0.0*), open either a terminal from the toolbar at the bottom of the screen or a new `xgterm` by right clicking the mouse within the desktop, and selecting `xgterm` from the menu.
   - Type `xhost +flmn-4m-1a` to allow remote display to *tan* from *flmn-4m-1a*.

3. Using the `xgterm`, `ssh` into the FLAMINGOS control computer, hereafter known as *flamingos1a*, as `4mguest`:

   ```
   4meter@tan%   ssh -X -l 4mguest flmn-4m-1a
                 password = _________
   ```
   (See the FLAMINGOS binder of manuals for the password).

4. Start `ds9` on *tan*'s center monitor

   ```
   4mguest@flmn-4m-1a{1}   ds9 &
   ```

5. Set the display to *tan's* right monitor *(tan:0.2),* open an `xgterm`, and start `IRAF`:

   ```
   4mguest@flmn-4m-1a{2}  setenv DISPLAY tan:0.2
   4mguest@flmn-4m-1a{3}  xgterm -T IRAF_Flamingos -n IRAF_Flamingos &
   ```

   In the `xgterm` you just opened start `IRAF` in the correct directory:

   ```
   4mguest@flmn-4m-1a{4}  cd ~; cd Iraf; cl
   ```

6. Move the cursor back to the xgterm on *tan:0.0,* set the display to *tan's* left monitor, open an `xterm`, and initialize FLAMINGOS.

   ```
   4mguest@flmn-4m-1a{5}  setenv DISPLAY tan:0.1
   4mguest@flmn-4m-1a{6}  xterm -T FLAMINGOS -n FLAMINGOS &
   ```

   Type all following FLAMINGOS commands within this `xterm` (appropriately titled FLAMINGOS).

7. You are now ready to initialize FLAMINGOS! This is done by running the command `initflam.pl`. This script initializes agents and displays the following windows:

   Temperature Daemon - This daemon reads temperatures from two different sensors in FLAMINGOS with the following output written to the screen:

   ```
   UFLakeShore208Agent::ancillary
   >new reading:(2002:170:05:24:06.920436) 1,75.67 6,82.73
   ```

   You should always keep an eye on the array temperature (~76 K, in the example above where it says `1, 75.67`) and the MOS dewar temperature (~83 K, where it says `6, 82.73` in the example above). The array temperature should never vary by more than ~0.5 K. The MOS dewar temperature must remain below 200 K for sucessful imaging. In normal operation the temperature varies between ~78 K and ~95 K in a sawtooth pattern, depending on the time since the last cryogen fill and the attitude of the instrument; if you are doing MOS observations, please do not let it warm up above 95 K, as the Decker and MOS wheel mechanisms may bind up. Please contact Dick Joyce, Ron Probst or Nick Raines if the MOS dewar deviates from this behavior.

   Record Temps window - This window logs both temperatures every 10 minutes. It is sometimes easier to monitor the array and MOS dewar temperatures from here. Please do not close this window or the associated `xterm` to which messages are printed; you can minimize the `xterm` messaging window.

   Motor Daemon - This daemon controls the motors which move all of the wheels. If the motor daemon does not initialize, answer `n` (for no) to `initflam.pl`'s query about continuing, close the motor daemon window and run `initflam.pl` again.

   MCE4 Daemon - This daemon runs the array controller, referred to as MCE4. The first time this daemon is run, if `initflam.pl` says it is not ready, look at the MCE4 daemon. If it is printing a string of messages about uninitialized semaphores, quit `initflam.pl`, close the MCE4 daemon window, and type `ufstop.pl -clean` at the `4mguest@flmn-4m-1a` prompt. Type `control-c` after `ufstop.pl` has printed several lines of text and has paused without returning the cursor. Then run `initflam.pl` once more.

   UFSTATUS GUI - This window displays the temperatures, the bias voltage on the array, and the positions of all of the wheels. Please do not close this window or the associated `xterm` to which messages are printed; you can minimize the `xterm`. Note that it is *NOT* updated automatically. Rather you must click the update button in the middle of the GUI for the most recent values and positions. *DO NOT* press the update button while any of the wheels are moving.

   Array Temperature Quick Look Plot Tool – This GUI will appear, along with an `xterm` messaging window. Please do not close this window or the associated `xterm` to which messages are printed; you can minimize the `xterm`. After about 30 minutes there will be ~3 points in the *Record Temperatures* log file, and you can hit the `Update` button to plot the present temperature.

   MOS Temperature Quick Look Plot Tool – This GUI will appear, along with an `xterm` messaging window. Please do not close this window or the associated `xterm` to which messages are printed; you can minimize the `xterm`. After about 30 minutes there will be ~3 points in the *Record Temperatures* log file, and you can hit the `Update` button to plot the present temperature.

During the first execution of `initflam.pl`, you will be asked at multiple points whether you wish to continue. In general, if the daemon windows say `listening on port`, startup has been successful and you should answer `y` (for yes). If you are re-running `initflam.pl` after rebooting MCE4 after a detector controller crash (*cf. § VII. Troubleshooting*), but have left the daemons running (which is ok), the script will complain that the Motor and MCE4 daemons are stalled, however these daemons are probably functioning properly and you can type `y` to continue on.

NOTE: The KDE desktops on *tan:0.0* and *tan:0.1* have available 4 desktops (see the desktop pager on the toolbar). Once `initflam.pl` has been run, it is convenient to send the temperature plotting windows to another desktop. Click on the top bar of the window with the right mouse button and select the 'send to desktop' command to pick a different desktop.

NOTE: We recommend that one close, ***and immediately restart***, all three daemons (*Temperatures, Motor,* and *MCE4*) once a day. You will also need to close the *Record Temperatures Window*, and to quit out of the two temperature quick-look plotting utilities. We recommend that you do this in the afternoon, *e.g.,* right before starting to take a set of pre-dinner dome flats or darks.

III.Nightly Startup Tasks

A. FLAMINGOS Setup

We recommend that you complete the following list prior to each night's observing.

1. *Restart all daemons, temperature logging and temperature plotting windows.* Please see the notes at the end of the previous section. The daemons should all be `Quit` (not `Closed`, as this just minimizes them), and `initflam.pl` immediately re-run, in order to restart the daemons.

2. *Fill Both Dewars.* At the 4-m the telescope operator should be in charge of filling the dewars with liquid nitrogen. Both the main dewar (the big one on the bottom) and the MOS dewar (the one on the top) need to be filled with liquid nitrogen at the start of *every* night before you can observe, and the MOS dewar also needs to be filled at the end of *every* night.

3. *Create a data directory for the night on flamingos1a and on nutmeg and start the autocopy script.*

   From any *flamingos1a* window:

   ```
   4mguest@flmn-4m-1a{1}  cd /data/4mguest/
   ```

   - Create a directory on *flamingos1a* with the UT date in the format YYYYMMDD (or whatever designation you prefer), *e.g.:*

     ```
     4mguest@flmn-4m-1a{1} mkdir 2003sep15ut
     ```

   - Create a directory on *nutmeg* with the *exact same name,* and make it world writable:

     ```
     4mguest@flmn-4m-1a{1} pushd /net/nutmeg/md4/4meter/Flamingos
     4mguest@flmn-4m-1a{1} mkdir 2003sep15ut
     4mguest@flmn-4m-1a{1} chmod a+w 2003sep15ut
     4mguest@flmn-4m-1a{1} popd
     ```

   - Verify that *flamingos1a* and *nutmeg* have enough disk space available. Typing `df -h` on *flamingos1a* shows the following output:

     ```
     Filesystem            Size  Used Avail Use% Mounted on
     /dev/dsk/c1t0d0s0     9.3G  1.3G  7.9G  15% /
     /dev/dsk/c1t0d0s1     9.3G  2.7G  6.5G  29% /usr
     /dev/dsk/c1t0d0p0:boot
                            11M  1.7M  9.0M  16% /boot
     swap                  951M   12K  951M   1% /var/run
     swap                  961M  9.2M  951M   1% /tmp
     /dev/dsk/c1t1d0s0      68G   29G   38G  44% /data
     /dev/dsk/c1t0d0s2      16G  2.5G   13G  17% /home
     nutmeg:/md4           100G   30G   66G  31% /net/nutmeg/md4
     ```

     In this example the data disk on *flamingos1a*, `/data`, is 44% full, and had `38 GB` of available space; the data disk on *nutmeg*, `/net/nutmeg/md4`, is 31% full, and has `66 GB` of available space. For imaging you should ensure that there is at least ≥`10 GB` of space available; for spectroscopy you

should have ~5 GB of space. However, note that the image acquistion scripts will complain on each and every image if the disk space is is ≥ 93% full, and will refuse to take any more data if the disk is ≥ 97% full.

- *Start the autocopy script.* After the image is created on *flamingos1a* a file with the suffix `unlock` will be created. The autocopy script monitors the night directory, and when an unlock file appears it copies the corresponding image to *nutmeg* and deletes the unlock file. To start the script:

```
4mguest@flmn-4m-1a{1} Start.autocopy.4m.nutmeg.sh
```

An xterm should pop up, with a summary of the above instructions:

```
--------------------- STARTUP INSTRUCTIONS ---------------------
1) Create the night's directory on flamingos1a in /data/4mguest

2) Create a directory with the same name on nutmeg, in
   /net/nutmeg/md4/4meter/Flamingos

3) chmod a+w the directory created on nutmeg

4) Enter the directory name (not the full path) at the prompt

--------------------- ENDING INSTRUCTIONS ----------------------
          After the final image has copied to
          nutmeg, ctrl-c or close the window.
----------------------------------------------------------------

Enter tonight's directory name:
```

Make sure you enter only the directory name (*e.g.* `2003sep15ut`), and not the entire path.

4. *Set up header information, data location, file names.* Once you have created a data directory, you need to tell FLAMINGOS where it is. Run `set.filename.pl`. This will prompt you to change the parameters `FILEBASE` and `ORIG_DIR`.

   - `FILEBASE` sets the root prefix for the image name; all image names will be of the format filebase.####.fits, where #### ranges from 0001 to 9999; the image number is incremented automatically.
   - `ORIG_DIR` sets the absolute path to the night's data directory. The entry here ***must*** have a trailing slash, *e.g.* `/data/4mguest/2003Mar31/`.

5. *Verify Position Angle*. The value of the parameter `ROT_PA` in `config.mos.dither.pl` should match the actual telescope position angle, which is shown near the bottom of the telescope status screen; the telescope operator can show you which number to read. The valid rotator range is `-0.6°` to `+180.0°`.

B. Startup on the Sky

Several of these steps refer to commands that are described in more detail in section ***§ IV. Imaging with FLAMINGOS*** (*e.g.* for details on how to configure the wheels and how to set the exposure time).

1. *Telescope operator's typical nightly tasks:*

- Opening the telescope and dome.
- Preliminary pointing check of a bright star on the North Port TV camera. The star should be located on the grease pencil x-mark on the monitor that corresponds to the FLAMINGOS hot spot.
- Focus telescope on North Port TV camera (in direct video mode, not on the guide camera).
- Measure seeing. Note that the seeing camera has a focus offset from the best focus on the North Port TV camera; if the seeing is measured after you have started observing, make certain the focus is returned to the correct value.

2. *Verify FLAMINGOS is set up for imaging*. The Decker and MOS wheels should be at their imaging positions, the Lyot wheel should be at the 4-m stop, and the Grism wheel should be at position `open1`. The K_s filter is quite useful for these startup tasks.

3. *Center a bright star to within 10 pixels of `(x,y) = [1024,1024]` on FLAMINGOS.*
   - Within `ds9` you can draw rulers from the approximate center of the star to the center of the array.
     - Double clicking on the ruler line will pop up a GUI with the length of the ruler line and its decomposition in detector `(x,y)` coordinates. The starting and ending `(x,y)` coordinates of the ruler are also listed and are modifiable.
     - Enter new values for the center of the star for one endpoint of the ruler, then enter in `(1024, 1024)` for the center of the array for the other ruler endpoint. Afterwards click the `Apply` button at the bottom.
     - Next, hold and select the `Distance` pulldown button and choose the `Arcseconds` distance scale. The numbers in the window will change accordingly.
   - Use `relative.offset.kpno.pl` δ`RA` δ`Dec` to offset the telescope.
     - Note δ`RA` and δ`Dec` must be in arcseconds (see the previous step).
     - Look at the compass arrows in `ds9` to determine which of `(x, y)` corresponds to (`RA, Dec`); you may have to darken the display to create enough contrast to see the arrows clearly. At the 4-m the instrument's default position angle is `90°`; under this condition, moving an object from its present location on the array by `(+dx, +dy)` in detector space corresponds to `(+dDec, -dRA)`.
   - Take another image, and iterate with rulers and `relative.offset.kpno.pl` until the star is centered.

4. *Ask the telescope operator to Zero the telescope pointing.*

5. *Verify optical alignments.* During the first pointing check of the evening, it is advisable to take an image of a very bright star way out of focus, to verify that the pupil stop has not been moved, and that the mirror covers and dome are open and positioned properly. You should see a bright donut, with shadows for the secondary and the spider vanes. If the donut is not circular (*e.g.*, has a sliver missing at the outer edge) there may be something vignetting.

6. *Optimize focus on sky near first target field.* The North Port TV camera should have been set up to be confocal with FLAMINGOS during the first checkout night. You should be able to tune the telescope focus on the TV camera and be close to best focus on FLAMINGOS. Then you should do a short focus run about that point (with steps of 50 units) on FLAMINGOS.

   - Use an exposure time ≥ 10 seconds to average over seeing fluctuations.

   We recommend using the tasks in the new `flmntools` `IRAF` package written by Anthony Gonzalez (UF) for assessing image quality. However you can also use the `IRAF` task `imexam`, in the standard manner. We

detail the use of both here.

- The `flmntools` tasks `fwcheck` and `fwscan` take differences of images, and then run `SExtractor` on the central `1250 × 1250` pixel region to determine the average `FWHM`; sources brighter than `10,000 ADU` in the difference image are ignored and objects with `FWHM < 1.3` pixels are rejected as cosmic ray hits. To use these, first enter the `flmntools` package to get the following prompt:

```
cl> flmn
 ~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
Welcome to FLMNTOOLS - The FLAMINGOS Observing Tools
 ~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

Tasks included are:

fwcheck   - Quickly check the fwhm and display the difference image
fwscan    - Compute the fwhm for each frame in a set of observations

      fwcheck  fwscan
fl>
```

  This package is used at more than one telescope, so on the off-chance that the parameters have been `unlearned`, verify the telescope field is set to `Mayall` (the 4-m):

```
fl> epar fwscan

PACKAGE = flmntools
   TASK = fwscan

root    =            ugc3371.j  Root infile name?
First   =                   21  First image in set?
Last    =                   25  Last image in set?
(telesco=                Mayall) Telescope(MMT,Mayall,KPNO2.1m)?
(mode   =                    q)
```

  - `fwscan` takes a range of images as inputs, in the form

```
fwscan <image root name> <First image number> <Last image number>
```

    It computes running difference images from which it computes the `FWHM`. You can use this to monitor the seeing during a sequence of observations. To use this for focus runs, *e.g.*

    - `4mguest@flmn-4m-1a{1} singleimage.pl`
    - `4mguest@flmn-4m-1a{2} relative.offset.kpno.pl 10 0`
    - Ask the operator to increment the focus (*e.g* `50 - 100` units).

    Repeat these three steps as necessary, offsetting the telescope back and forth between each image. Once you've taken 2 or more images `epar fwscan` to make certain it is setup for the 4-m, then run `fwscan`. Here's some sample output:

```
fl> fwscan p182e.j 1 9
#Main    Bkgd                          1st
#Frame  Frame   Average   Median    Quartile   #stars
 1       2     0.85''  0.83''       0.81''       51
 2       1     0.89''  0.88''       0.85''       49
```

```
3       2     0.82''  0.82''       0.77''       42
4       3     0.88''  0.87''       0.81''       45
5       4     0.91''  0.92''       0.82''       51
6       5     0.79''  0.80''       0.74''       39
7       6     0.86''  0.85''       0.79''       48
8       7     0.76''  0.76''       0.70''       45
9       8     0.82''  0.81''       0.78''       43
```

- `fwcheck` differences two frames, computes the `FWHM`, displays the difference frame in buffer 4 of `ds9`, and finishes with an `imexam` cursor on the image. To call it:

  ```
  fwcheck <image root name> <background image number> <source image
  number>
  ```

- Some notes on using `imexam`, in the standard manner:

  - After an image has displayed in `ds9` type `imexam` *with no arguments* at the `cl>` prompt[2]. You can keep `imexam` open as you continue to take focus images.
  - Use the `r`, `a`, and `e` keys to obtain information on the image quality.
  - We usually use the Moffat fit number (the second fit number from the right after hitting the `a` or `r` keys) for characterizing the image quality.
  - FWHM of `2 - 2.5 pixels` over the entire chip are good enough (`0.63 - 0.79 arcsec`).
  - Optimize focus on stars out about 350-500 pixels in radius from the center of the chip.
  - Stay away from the left edge of the chip, however, as it is slightly more out of focus than the rest of the array.

7. *Variation of focus with temperature.* The telescope changes focus due to temperature variations; as the temperature drops the focus will increase. The relation we have been using is:

   $$\Delta T(+1\ C) = -130 \text{ focus units}$$

   We frequently monitor the middle dome temperature, but there now is also a truss temperature monitor that the telescope operator can read for you. It's advisable to watch the temperature every 30 – 60 minutes, and if necessary adjust the focus on the TV camera.

NOTE: If the focus changes a large amount (2000 units) from one night to the next, verify that the ADC prisms within the guider are out of the beam. They have been known to move into the beam without being expressly commanded to do so.

You are now ready to start observing!

2 Note that if you type in the image name, `iraf` will have to redisplay the image and possibly will not choose a useful image scaling; it will also disable the scaling buttons in `ds9`. It is generally better to use `ds9`'s `file open` in order to display an image rather than type `display` in `iraf`.

IV.Imaging with FLAMINGOS

A. Overview

FLAMINGOS may be used for imaging through J–, H–, K–, and K_s-band filters. Sky emission in these bands is variable and may be bright[3]. Exposure times are kept reasonably short as a result and guiding is not required. The general observing procedure is to point the telescope in a dither pattern about the source. FLAMINGOS has a dither script with several different dither patterns available. They all are oriented in a square grid in (RA, Dec); the ordering through the pattern is executed in the same psuedo-random order every time (it is not a raster).

For deep imaging exposure times up to 120 seconds in the J-band, and up to 30 – 90 seconds in the H– and K-bands are common. The shortest possible exposure time used with FLAMINGOS for scripted observing is 2 seconds. There is also a special script which will take a single exposure at the fastest possible exposure time of 1500 milliseconds (mS) immediately upon execution.

N.B.: FLAMINGOS has two integration timers, a milliseconds timer for exposure times ≤ 60 seconds, and a seconds timer for exposure times ≥ 60 seconds. The seconds timer was determined to have a total timing error range of ~ 1 second[4]; the array controller hardware code was updated during August 2003, and this problem should have been eliminated; however, we have not yet evaluated the engineering data. Some observers choose to use 60 seconds as the maximum exposure time they will use for their observations, in order to use only the mS timer.

The default bias for imaging is 1.0 V; the present value may be obtained by hitting the Update All Items button on the UFSTATUS GUI. The MCE4 array controller supplies this bias automatically on boot, after initflam.pl has been executed.

The general outline for imaging observations is as follows:

1. Set Instrument Position Angle.
2. For every new target, verify telescope pointing on a SAO or Fixed Bright star close to the target position. Do so by imaging the star on FLAMINGOS; offset the telescope until it is well centered on the array, then have the telescope operator Z the telescope (*cf. § III. Nightly Startup Tasks: B. Startup on the sky).*
3. Acquire target close to the center of the FLAMINGOS field of view (FOV).
4. Check focus.
5. Execute imaging dither pattern.
6. Repeat steps 1 – 5 on standard; we usually use the Persson standards (see the FLAMINGOS binder). The telescope operator's cache identifies these as HST/NICMOS standards.
7. Take any required dome flats. These may be done in the afternoon.
8. Take darks (~20 each) at every exposure time that was used. These may be done in the afternoon.

The following list of commands is useful for imaging and for spectroscopy (described in the next section). A more detailed explanation of several of these scripts directly follows the list.

---

3 In the in the H and K-bands the emission is mostly generated by OH in the atmosphere at elevations of 90 km.

4 Mark Dickinson discovered this problem. See his analysis at: www-int.stsci.edu/~med/flamingos/fewompt_plus.html.

On the FLAMINGOS command line:

`config.dither.kpno.pl`	Use to setup a sequence of images dithered about a common pointing center.
`config.exposure.pl`	Set filename, storage directory, exposure time, and number of reads, as well as several descriptive fields.
`config.filter.grism.decker.wheels.pl`	Insert filter, grism and appropriate baffle on decker wheel.
`config.mos.wheel`	Use to select the MOS wheel imaging hole.
`dither.source.kpno.pl`	Executes data acquisition in the selected pattern.
`fast.singleimage.pl`	Immediately take a single 1500 `mS` exposure time image.
`more.singleimages.pl <n>`	Take `n` consecutive images with the present system configuration.
`offset.kpno.pl <dra> <ddec>`	Offset telescope with respect to base pointing center.
`relative.offset.kpno.pl <dra> <ddec>`	Offset telescope with respect to present pointing center.
`set.bias.pl`	Use to set the detector bias voltage; shortcuts for imaging (`i`) and spectroscopy (`s`) may be typed to select common values.
`set.exposuretime.pl`	Alternative way to set integration time (seconds) and number of reads only.
`set.filename.pl`	Alternative way to set the filename and data directory only.
`singleimage.pl`	Take a single image with the present system configuration.

B. Wheel Setup for Imaging

FLAMINGOS has five wheels in its optical path, each containing various filters, pupil masks, and spectroscopic slits. Hit the `Update All Items` button on the UFSTATUS GUI to determine the present location of the wheels. In imaging mode the following configuration should be in place:

- Decker Wheel (motor `a`) should be set to `imaging`.
- MOS Wheel (motor `b`) should be set to `imaging`.
- Filter Wheel (motor `c`) should be set to one of the following bandpass filters: `J, H, K, Ks, JH, HK`.
- Lyot Wheel[5] (motor `d`) should be set to `4-m`.
- Grism Wheel (motor `e`) should be set to `open1`.

If all you plan to do is imaging, then the you should not need to adjust the Decker or MOS wheels. If the MOS wheel is not positioned correctly, use `config.mos.wheel.pl` to select the imaging aperture. Use `config.filter.grism.decker.wheels.pl` to set the indicated wheels. The Lyot wheel should not need to be adjusted. Each of these scripts will first query and then print the present motor positions.

- The MOS script will query if you wish to change the setup; answering `y` will cause a list of 17 named positions to appear. Type `10` to select the imaging hole. Next, the script prints out a detailed information window, the last bit of which shows the desired move. Answering `y` at this point will issue the wheel motion command.
- For the filter/grism/decker script, type the motor name (`c`, `d`, or `a`, respectively) before acquiring a list

5 If the power to the motor controller has been cycled, the GUI will claim that the lyot wheel is at `Hartmann1`. The Lyot wheel should have been set during the first engineering night of the FLAMINGOS run at the 4-m, and should not need to be adjusted.

of valid positions. Note that position `0` for each wheel is the home position. As with the MOS script, the script will print out a detailed information window, the last bit of which shows the desired move. Answering `y` at this point will issue the wheel motion command.

For both scripts the wheel motion status will be queried approximately every 5 seconds, and the result will be printed to the screen. It is unnecessary to hit the `Update All Items` button on the `UFSTATUS GUI` during execution of either of these scripts. It is, however, a good idea to update the GUI after the script has successfully completed.

Note:

- It is not possible to move more than 1 wheel at a time.
- The only useful dark position is on the grism wheel; there is a dark position on the Decker wheel, but its use is not recommended.
- Once the script has started moving a wheel, do not attempt to abort it. Just wait for it to finish moving, and run the script once again.

C. Configuring an Exposure

Several parameters need to be set before taking an exposure. The script `config.exposure.pl` will print out a list of exposure parameters, and query if you wish to change any of them. If you do, you can step through each of the modifiable parameters; enter the new value or hit return to keep the old value. Here is a complete list of parameters that are printed out:

`OBS_TYPE` — Type of observation being taken; commonly used descriptors include `object`, `standard`, `flat`, `dark`.

`OBJECT` — Name of object being observed. **NOT** provided by TCS.

`FILEBASE` — Image filename's prefix; the naming convention is `filebase.####.fits` where the numbers (`####`) are automatically incremented by the data taking script from `0001` to `9999`.

`ORIG_DIR` — Absolute pathname of the directory to which you wish to write data. Make sure you include the trailing / on the pathname.

`DATE_OBS` — UT date at the end of the night (YYYY-MM-DD).

`EXP_TIME` — Exposure time for integration in *seconds*. Must be an integer `>= 2` and `>= 2 NREADS`.

`NREADS` — Integer number of non-destructive reads per endpoint per image.

- For imaging use `NREADS = 1`, which corresponds to Correlated Double Sampling (CDS).
- For spectroscopy you can use multiple read sampling:
  - The minimum value is `NREADS = 3`.
  - The maximum recommended value is `NREADS = 8`.
  - The minimum allowable `EXP_TIME` is `2×NREADS`.
    - Note that this script does not always rigorously enforce this condition, so please double check that `EXP_TIME` and `NREADS` are mutually consistent.
- For `NREADS > = 3` the output image will have signals `NREADS` times higher than for a CDS frame; *i.e.,* the output image is a coadd, not a coaverage frame.
- A schematic of the readout scheme appears in Figure 3, in the appendices.

`BIAS` — The value of the *last requested bias* is recorded here. `1.0` corresponds to the imaging bias at `1.0 V`; `0.75 V` corresponds to the spectroscopic bias where the dark current is substantially lower even though the well depth is a bit lower than at `1.0 V`. *To determine*

the actual present bias value hit the Update All button on the UFSTATUS GUI.

WEATHER	A numerical descriptor of common environmental conditions (1=photometric, 2=thin cirrus, 3=broken clouds, 4=overcast, 5=snowing, 6=fog).
WIND	A numerical range descriptor of the wind speed (1=calm, 2=low, 3=moderate, 4=high, 5=closed).

After prompting you for all of these parameters, `config.exposure.pl` will ask if you want to change the bias. If you do it will automatically run the script `set.bias.pl`. In imaging mode, the bias should always be set to 1.0 V.

If you wish to change just the exposure time or the filename, and don't want to run through the entire list of parameters, then use any of the `set.exposuretime.pl` or `set.filename.pl`.

D. Taking Images at a Single Pointing

The most useful script for quickly looking at an image with the present telescope pointing and instrument configuration is `singleimage.pl`. This takes an image immediately upon hitting return and displays in `ds9`.

E. Taking Dithered Images

FLAMINGOS also has the ability to take a sequence of images using a set of pre-determined dither patterns. In order to configure the dither pattern, run `config.dither.kpno.pl`. This allows you to change the following parameters:

DPATTERN	The desired dither pattern. Your choices are `2x2`, `3x3`, `4x4`, `5x5`, `5box`, `5plus`, and `45rot_5x5` pattern rotated by 45 degrees. The offsets always are in the form of `(`δ`ra, `δ`dec)`. The `5box` pattern is the `2x2` pattern with the central pointing; `5plus` is the `5box` pattern rotated by 45 degrees.
D_SCALE	Additional scale factor for the offsets. The default of `D_SCALE = 1` will add a border to your images of `15 arcseconds`, for a net increase of `30 arcseconds` to the total field of view of the final stacked image, *for any of choice of `DPATTERN`.*
D_RPTPOS	Number of times to repeat each dither position.
D_RPTPAT	Number of times to repeat the entire dither pattern.
STARTPOS	Starting position in the dither pattern, where `0` is the first position of the pattern. This is very useful if the system crashes or hangs mid-sequence, however do not forget to reset it back to `0`.
USENUDGE	Nudge pointing center on pattern repeats; `0 = do not nudge`, `1 = perform nudge`.
NUDGESIZE	Radial size in `arcseconds` of nudge, randomly chosen in one of the cardinal (`ra, dec`) directions.
THROW	Radial length in `arcseconds` to other nod beam (not functional in imaging mode).
THROW_PA	PA of other beam for nodding (not functional in imaging mode).

After you have configured your dither sequence, run `dither.source.kpno.pl` to execute the dither pattern and take images. Immediately after hitting return this script print out information about the requested dither pattern, and it will ask you to type either `HOME` or `CLEAR` before beginning to execute the dither pattern.

If you have any offsets showing on the TCS, typing `HOME` will cause the script to dither about the pointing center where the offsets are `(0, 0)`, while typing `CLEAR` will absorb any offsets present into the current

pointing coordinates, and dither about that new position. See the next section on offseting the telescope from the FLAMINGOS command line.

You can monitor seeing variations and any focus drift if you continuously use `fwscan` while the dither pattern executes; just start using it after the first two images have read out.

F. Offseting the Telescope from Flamingos1a

At certain times (such as pointing checks or adjusting the position of your sources on the detector) you may wish to offset the telscope directly from *flamingos1a* rather than having your operator do it. To do so use the following commands:

`offset.kpno.pl <RA> <Dec>` - Offsets of the telscope in a *absolute* sense with respect to the pointing center (where the telescope offsets are (`0, 0`)). Offsets are in arcseconds and positive values move the telescope East and North from the pointing center where the offsets are `0, 0`. For example, `offset.kpno.pl 5 10` will set the telescope pointing 5 arcseconds East, and 10 arcseconds North. Repeating this command with the same offsets will not move the telescope.

`relative.offset.kpno.pl <RA> <Dec>` - Offsets of the telescope *relative* to wherever the telescope presently is pointed. Offsets are in arcseconds and positve values move the telescope East and North from the telescope's current position. In this case, `relative.offset.kpno.pl 5 10` will move the telescope 5 arcseonds East and 10 arcseconds North. If the offsets initially were (`0`, `0`) then after this move they will be (`5`, `10`); repeating this command will move the telescope and the new net offsets will be (`10`, `20`) arcseconds.

Typing `offset.kpno.pl 0 0` will send the telescope back to the starting pointing center.

Typing `clear.offsets.kpno.pl` will allow you to define the present net pointing (base plus offsets) as the pointing center. It will cause the telescope to absorb the present offsets, i.e., the offsets on the TCS will reset to `(0, 0)` but the telescope will not move.

G. Taking Darks

Darks need to be taken at every exposure time that was used for observation on the sky. Generally 10 – 20 images are taken per exposure time, for averaging; they are usually taken sometime during the daytime. To take a single set of images at the same exposure time, use the script

```
more.singleimages.pl <number of images desired>
```

If the required darks have a long exposure time, consider starting them going as you walk out the door to go to bed. *Be very certain to check on the quality of the data once you get up*—the array controller may hang midway through the data set, or have a glitch which affects some of the images.

If you need to take many darks at several different exposure times, consider writing a cshell (`csh`) script which consecutively calls `config.exposure.pl` and `more.singleimages.pl` multiple times, each time passing the proper keystrokes into each script. An example, based on a script written by Anthony Gonzalez (UF), appears in

```
~4mguest/bin/Example.many.scripted.darks.csh
```

Note that the blank lines are very important!

Also, be very certain to check later that the script completed successfully; *cf. § VIII. Troubleshooting* for possible failure modes, such as bad reads, scrambled images, zero frames, and MCE4 hangs.

V. Taking Spectra with FLAMINGOS

A. Overview

FLAMINGOS may be used for obtaining long slit or multi-object slit spectra; please see Section *I. FLAMINGOS + KPNO 4-m Overview* for resolving powers within selected passbands. As with imaging, the sky emission is variable and bright. It is necessary to subtract this contribution from the target spectrum. To this end, observers generally dither the target up and down the slit. Two modes that we use include walking up the slit at 5 to 7 different locations, and nodding the telescope back and forth between two offset positions, or beams, `A` and `B`, in an `ABBA` pattern, symmetrically placed about the target's initial alignment position. Dithering in an `ABBA` pattern can be done by hand, or automatically with a script. Walking up or down the slit must be done by hand.

Telescope guiding is required, as the integration times are generally long, and the time to align a long slit or MOS plate is also significant. The South Port guide probe `(x, y)` location is shown on the TCS Video unit. The radius, $r = \sqrt{(x^2 + y^2)}$, from the center of the field of view ***must be ≥100 mm*** or else the guide probe will vignette the FLAMINGOS field.

The default bias for spectroscopy is `0.75 V`, where the array has lower dark current than at the imaging bias of `1.0 V`. The present bias value may be obtained by hitting the `Update All Items` button on the `UFSTATUS GUI`. ***N.B.:*** the MCE4 array controller automatically set the bias to `0.776 V` on boot, which is not a bias voltage used in any configuration. The initialization script `initflam.pl` sets the bias to `1.0 V`, and then queries whether you wish to change the bias. *If MCE4 crashes and you have to run `initflam.pl`, don't forget to reset the bias for spectroscopy!*

The general outline for spectral observations is as follows:

1. Set Instrument Position Angle (PA) to match the slit PA.
2. Verify telescope pointing on a SAO or Fixed Bright star close to target position.
3. Acquire target close to the center of the FLAMINGOS field of view (FOV).
4. Check focus.
5. Acquire a guide star and start guiding.
6. Insert appropriate decker baffle (long slit or MOS) and check its alignment.
7. Insert and align long slit or MOS plate.
8. Insert desired filter and grism.
9. Set bias to `0.75 V` for spectroscopy.
10. We recommend that one take quartz or dome flats after the target observations to avoid loss of guiding which can occur if flats are taken prior to the target observations.
11. Take a junk spectrum.
12. Configure spectral dither pattern parameters.
13. Execute spectral dither pattern.
14. Take all of the required quartz or dome flats, and HeNeAr wavelength calibration data if desired.
15. Repeat steps 1 – 14 with the long slit on a bright telluric standard star (G5-6 V) close by on the sky.[6]
16. You may want to take a long slit spectrum of an A0 star at low airmass as well.
17. Take darks (~20 each) at every exposure time that was used for flats, wavelength calibrations, science target spectroscopy, and standard star spectroscopy. Be sure to use the spectroscopy bias of `0.75` V.

6 If you intend to use the 3-pixel MOSplate long slit, you can leave the decker positioned at the MOS baffle.

These may be done in the afternoon.

The following list of commands is used for long slit and MOS plate spectroscopy:

On the flamingos command line:

`config.exposure.pl`	Setup the filename and exposure time.
`config.filter.grism.decker.wheels.pl`	Use to insert filter and grism and appropriate baffle.
`config.mos.wheel.pl`	Use to insert long slit or MOS plate.
`config.mos.dither.kp4m.pl`	Setup the spectroscopy ABBA parameters.
`dither.mos.kp4m.pl`	Take the spectrosopy ABBA data.
`set.bias.pl`	Use to change bias for imaging or spectroscopy.
`tweak.decker.pl <delta_angle>`	Allows adjustments to the Decker wheel position.
`tweak.mos.pl <delta_angle>`	Allows adjustments to the MOS wheel position.

At the iraf cl prompt:

`imexam`	Measure slit profiles and stellar centers (keys: `a, x, g, i`).
`xbox`	Use to align a MOSplate (keys: `q, f, g`).

B. Long slit Alignment

1. *Set instrument PA before acquiring target.*
   - This must be done first, as the telescope must be at zenith in order to move the rotator.
   - For safety reasons, have the telescope operator make the rotation from the Cassegrain Cage.
   - Run `config.mos.dither.kp4m.pl`, and set the parameter `ROT_PA` to the new value, so the WCS compass arrows will display correctly in `ds9`.
2. *Have telescope operator verify pointing on the North Port TV Camera.*
   - Use an SAO star or a Fixed Bright Star near to target field.
   - There should be a grease pencil mark on the TV monitor indicating where to zero the telescope pointing.
   - Take a quick image (`2-5` seconds) on FLAMINGOS, and make certain the SAO star is well centered on the array. If is not, center the star with `relative.offset.kpno.pl`, then take another image. Once it is well centered, `Z` the telescope *(cf. § III Nightly Startup Tasks: B. Startup on the sky*).
3. *Acquire target on FLAMINGOS in K_s filter.*
   - If necessary, adjust telescope pointing with `relative.offset.kpno.pl` until target is positioned close to the center of the array.
4. *Have the telescope operator adjust focus.*
   - The guide camera should be confocal with FLAMINGOS and should give a good starting focus.
   - Next, take a series of images over a range that covers best focus, offsetting the telescope between each image; use `relative.offset.kpno.pl` and dither back and forth by 10 – 20 arcseconds. Run `fwscan` on the stack of images to determine the best focus setting (*cf. III. Nightly Startup Tasks, §B – Startup on the Sky*).
   - Don't spend very long on this, as the focus will change.
   - Record the middle dome temperature, for reference.
5. *Have the telescope operator acquire a guide star, and begin guiding.*
   - Verify that the guide probe radius is greater than `100 mm`, in order to avoid vignetting.
6. *Take another image with FLAMINGOS, and measure the target's centroid.* Use `imexam`, key `a`.
7. *Insert decker long-slit baffle* using `config.filter.grism.decker.wheels.pl`.
8. *Verify decker long-slit is straight* along the chip (small *dx* for a large *dy*).

- The easiest way to check the straightness of this wide slit is to draw a ds9 ruler parallel to one edge. Then double click on the ruler, to find out the angle. It probably should be within 0.05° of 90°.
- A more accurate method is to use imexam and j to fit a gaussian to a cross-cut through the slit at two different *y*-values. Record the fitted peak (x-coordinate) and the y values, and compute the angle arctan(dx / dy) if dx is > 1.5 pixel.
- You may need to epar jimexam, and set the estimated sigma to 15 pixels, since this slit is very wide.
- If dx is > 1 pixel, reorient the decker slit using tweak.decker.pl.

9. *Now insert MOS wheel long-slit.* Use config.mos.wheel.pl.
10. *Verify long slit is straight.*
    - Use imexam, as described in step 8, and measure across the slit with the j key at two different positions. If dx is > 1 pixel, you should reorient the slit using tweak.mos.wheel.pl.
    - Don't forget to reset jimexam if you modified any parameters earlier when inserting the decker.
11. *Measure x-location of straightened slit,* **at the location you want to position the star/galaxy.**
    - Use imexam and the j key.
    - *We recommend caution if positioning the target at the center of the array.* This is because the last 8 rows of pixels in quadrants 1 and 3 *(i.e.* (x, y) = [1:1024,1025:1032] and [1025:2048,1017:1024]) are sometimes corrupted; the rows are parallel to the dispersion direction. If the distance between the MOS dithering beams is less than 10", one of the two halves of the spectrum runs the risk of being corrupted.
12. *Use relative.offset.kpno.pl to move the star onto the slit.*
    - To quickly estimate the distance to move, draw a large ruler in ds9, and then double click on it to get its pop-up GUI. Enter the (x, y) coordinates of the star, and the destination position along the slit. Then click on the Distance pulldown menu, and select Arcseconds.
    - You may need to iterate with this step, and peak up the flux from the object through the slit.
    - ds9's display parameters may be adjusted to see the diffraction spikes if the star is quite bright, and you can tell if the star is well enough centered on the slit; try zmax and log scalings.
    - We frequently align MOS plates to ~0.15", however note the telescope pointing is finicky for offsets smaller than 1".

C. MOS Plate Alignment

Mask alignment on FLAMINGOS is done using a modified version of the IRAF task xbox, from the UCSCLRIS package. A mask should have 2 – 4 boxes (in addition to the slitlets) which correspond to bright alignment targets. Given an image of the mask, and two files, one containing the approximate locations of the boxes, and one containing the corresponding star locations, xbox will allow you to quickly determine the translational and rotational shifts required to center these targets in their corresponding boxes.

It will output translational offsets, in arcseconds, that should correspond to (δ RA δ Dec), and a rotational offset in degrees. The 4-m instrument rotator is not very precise and cannot be adjusted when not at the zenith, so it may not be used for the rotational offset. As a result, the MOS wheel must be rotated instead. After every translation and/or rotation a new image must be taken, and new box and star files generated.

There are 10 important parameters that should be double checked against the complete listing of the xbox parameters given in **Appendix 3**. There are three parameters that you may need to change:

1. xsz and ysz
    - The widths in pixels of the alignment boxes in the x and y directions.
    - All of the boxes are of the same size.

- We typically use alignment star boxes that are 24 – 30 pixels wide. It is very important that this parameter be set to within a few pixels of the actual values.

2. rot_4m
   - This is listed as the 4-m rotation offset, and it should directly correspond to the instrument position angle. We have experimentally determined that it works for position angle of 90 degrees:
     - If ROT_PA = 90: set rot_4m = −90.

Running xbox causes a graphics terminal to pop up. It steps through the boxes, in the order listed in the box file, and presents a cross-cut profile for the x and y directions, along with a red graphics cursor. It will show the estimated location of the box along the bottom of each cut, along with a horizontal threshold level through the cut, and a vertical line indicating the estimated location of the peak of the alignment target; the first time through there likely will be no targets in the boxes, and the line will be centered on a noise peak.

You can adjust the position of this vertical line, say if xbox detects the wrong peak, once the alignment targets are in their boxes by moving the cursor to the correct location and hitting the f key. Hit q after looking at the fits for every box, and the final graphical presentation of the estimated adjustments. Afterwards, xbox will print out a lengthy set of values used for computing the offsets. The final bit of this indicates how much to move the telescope and rotator. Here is example output from xbox for a plate with ROT_PA = 90 (and rot_4m = −90):

```
================================================

*** MOVE TELESCOPE/ROTATOR by the following offsets:

 Offset PA by -0.06 (0.01) degree
 Offsets:  -4.38" (1.09)          30.60" (0.21)

================================================
```

The above translational offsets are printed in the order (δ RA δ Dec); also shown are estimated errors. Translational offsets smaller than 0.5 pixel = 0.16" may be ignored; rotational offsets down to 0.01 degree probably should be done.

Here is a step-by-step list of how to align the MOS plate:

1. *Set instrument PA before acquiring target.*
   - This must be done first, as the telescope must be at zenith in order to move the rotator.
   - For safety reasons, have the telescope operator make the rotation from the Cassegrain Cage.
   - Run config.mos.dither.kp4m.pl, and set the parameter ROT_PA to the new value. Now the WCS compass arrows will display correctly in ds9.
2. *Verify that the xbox parameter rot_4m is correctly set for the PA.*
3. *Have telescope operator verify pointing on the North Port TV Camera.*
   - Use an SAO star or a Fixed Bright Star near to target field.
   - There should be a grease pencil mark on the TV monitor indicating where to zero the telescope pointing.
   - Take a quick image (2–5 seconds) on FLAMINGOS, and make certain the SAO star is well centered on the array. If is not, center the star with relative.offset.kpno.pl, then take another image. Once it is well centered, Z the telescope *(cf. § III Nightly Startup Tasks: B. Startup on the sky*).
   - If the target field is too faint, or does not have any stars, consider adjusting focus on this pointing check field (*cf.* 5 & 6, below).
4. *Load the mask design image and region file* into buffer 3 of ds9.

- The images are usually kept in `/data/4mguest/Maskfiles/`.
- Flip and rotate until the image WCS matches that of a raw FLAMINGOS frame.
- Turn on tiling, with a vertical orientation; tiling of buffers 1, 2, and 3 is useful. Hide buffer 4.

5. *Acquire target on FLAMINGOS in K_s filter.*
   - Set exposure time to pick out aligment targets. Try an exposure time of 10 – 30 seconds if they are bright, but do not let them saturate. You may need to use much longer itimes (60 – 120 seconds) if they are very faint.
   - Attempt to visually pick out the alignment targets (stars or galaxies).
   - If necessary, adjust telescope pointing with `relative.offset.pl` until the targets are within the central region of the array.
   - If targets are faint, you may need to offset a small amount (`20 arcsec`) and work on a difference image. See the comments at the end of this section on how best to do this. Integration times may need to be increased, too.
6. *Have the telescope operator adjust focus on the TV camera*,
   - The guide camera should be confocal with FLAMINGOS, and should give a good starting focus.
   - Next, take a series of images with FLAMINGOS over a range that covers best focus, offsetting the telescope between each image; use `relative.offset.kpno.pl` and dither back and forth by `10 – 20` arcseconds. Run `fwscan` on the stack of images to determine which focus setting was best (*cf. III. Nightly Startup Tasks, §B – Startup on the Sky*).
   - Don't spend very long on this, as the focus will change.
   - Record the middle dome temperature.
7. *Have the telescope operator acquire a guide star and start guiding.*
   - Verify that the guide probe radius is greater than `100 mm`, in order to avoid vignetting.
8. *Insert the decker MOS baffle* using `config.filter.grism.decker.wheels.pl`.
9. *Verify the decker is straight* (check the edge of the decker MOS baffle); use `tweak.decker.pl` if necessary *(cf.* the previous section on long slit alignment).
10. *Measure the star centroids* and write them to a stars file for `xbox`:
    - `imexam logf=stars keep+`
    - Type `a` on each star
11. *Insert MOS plate* using `config.mos.wheel.pl`.
12. *Check the plate is straight* on the array with by stretching the display to see the plate frames. If it looks noticably unstraight, use a `ds9` ruler to estimate the offset angle and adjust it with use `tweak.mos.pl` (*cf.* the previous section on long slit alignment).
13. *Measure the box centers* and write them to a box file for `xbox`. **Measure the boxes in the same order as you measured the stars.**
    - `imexam logf=box1 keep+`
    - type `e` to generate a contour map
    - type `g` to get the graphics cursor
    - center the cursor on the box and type `x`
    - type `i` to return the image, and repeat this process for the other boxes.
    - If you cannot see the box well in the contour plot, consider starting over after setting the upper contour limit threshold to ~5,000 ADU; use `epar eimexam` and change the upper limit from the default value of `indef`.
14. *Run xbox:*
    - Type `epar xbox`
    - Set the parameter `image` to the most recent mask image
    - Set the parameter `input = box1`(the log filename you used in `imexam`)
    - Set the parameter `stars = stars` (the log filenames you used in `imexam`)

- Type `:go`
- An `xgterm` window with two cross-cut plots through the box, one each for the `x` and `y` axes will pop up.
- Type `q` to step through each of the boxes in the graphics window. If the box center is not clearly detected, use the `f` key to force the center, and `g` to force the signal threshold.
- After the last box it will pop up a window showing graphically how much each box must move to acquire the aligment target. Type `q` again.
- `xbox` finally will print out how much to rotate the MOS wheel (in degrees) and offset the telescope (in arcseconds). When `xbox` is configured for the present 4-m setup, the offsets printed out should directly correspond to the offsets to type to offset the telescope (see above).
  - Use `relative.offset.pl` δ`RA` δ`Dec` to offset the telescope.
  - Use `tweak.mos.pl` to rotate the MOS wheel by the amount suggested.
  - Translational offsets `> 0.5 pixel ~ 0.2 arcseconds` and rotational offsets `> 0.01 degrees` should be performed.

15. *Take another image.* At this point you should have stars in boxes. See the following notes on what to do if the alignment targets are so faint as to require long integrations and background subtraction.
16. *Remeasure the boxes* with `imexam` and make a new box file, if a `tweak.mos.pl` was required previously.
17. *Run `xbox` on the latest image:*
    - Set the parameter `image` to the new mask image
    - Set the parameter `input` to the new box file
    - Set the parameter `stars` to be blank
    - Type `:go`, and run through each of the graphics windows. Type `q` if the correct peak has been detected, otherwise move the cursor to the correct peak, and type the `f` key to select it.
18. Iteratively repeat steps 12 – 14 until the suggested offsets converge. With experience and some luck, this procedure should not take more than 15 – 20 minutes.

If the alignment objects are faint, you may need to run `xbox` on images with some of the sky flux subtracted. To do this, take an image with no stars in boxes and subtract a scaled version of this image from an image with stars in boxes:

- `relative.offset.kpno.pl 0 10` to move stars out of boxes (*n.b.* you are always guiding after step 7).
- `singleimage.pl` to generate image `sky.0001.fits`
- `relative.offset.kpno.pl 0 10` to move stars back into the boxes.
- `singleimage.pl` to generate image `object.0001.fits`
- `imarith 0.8 * sky.0001.fits scaled.sky.fits`
- `imarith object.0001 - scaled.sky diff.1.fits`
- now run `xbox` on `diff.1.fits`; if you wish to look at it, load it in `ds9`.

N.B. After every rotation of the MOS plate you must repeat this process of taking a sky image before taking a new image with the targets in their boxes, because the location of the box has changed on the detector array. However, if you have not rotated the MOS plate, you can use an old scaled sky image for subtraction.

D. Taking Spectra Once the Slit or MOS Plate is Aligned

There are two options for taking data once the target is aligned onto the long slit or MOS plate. The first option is to manually perform the dither pattern, taking individual images after each offset. We sometimes do this for long slit data of calibration stars, if we want to walk the star along the slit in a pattern other than an `ABBA` pattern. We frequently use the standard `ABBA` dither script for the long slit data, and seldom do not use it for the

MOS plate data.

Walking up the slit:

- We usually move up the slit in steps of `10"` for a total of `5-7` positions.
- Use `singleimage.pl` to take an image by hand at every location.
- Use `relative.offset.kpno.pl` to move the star up and down the slit (while continuing to guide).

Setup to execute a dithered ABBA script:

1. *Zero the telescope offsets*; type `clear.offsets.kpno.pl` and type `y` at the prompt.
2. *Insert filter and grism combination* with `config.filter.grism.decker.wheels.pl`.
3. *Verify bias* is set to `0.75 V` for spectroscopy when prompted after moving the grism wheel.
4. *Configure filename and exposure time*.

   For all spectroscopic observations we now recommend taking quartz or dome flats only after the target observations (*cf.* Step 8). More details may be found in the next section on calibrations.

5. *Take a single junk frame.* Set the exposure time to the same exposure time you want to use on your object. You should do this because the first image taken in low-flux conditions after being in high-flux conditions has lower counts than normal. For example, the alignment or calibrations might be taken at 30 seconds and the object taken at 300 seconds, so you need to take a junk image at 300 seconds before taking any real data.
6. *Configure the spectral dither sequence* using `config.mos.dither.kp4m.pl`.
   - Make certain the PA is correct.
   - Set `M_RPTPAT` to the number of times to repeat the pattern.
   - Set `M_THROW`, the distance in arcseconds between the `A` & `B` beams (which are symmetrically offset about the telescope zero point). For MOS observations we use `4 arcseconds`.
   - If `USEMNUDG = 1`, the `ABBA` pattern will be offset along the slit by `M_NDGSZ` (in arcseconds) on pattern repeats. For MOS observations we use `M_NDGSZ = 0.3`. Alternatively, one can execute the dither sequence with one `ABBA` pattern at a time, and use `relative.offset.kpno.pl` and `clear.offsets.kpno.pl` before repeating the `ABBA` pattern. Just keep track of the size and number of offsets.
7. *Start spectral dither sequence*, `dither.mos.kp4m.pl`. Repeat as necessary.
8. *Take one or more sets of quartz or dome flats at end of spectral dither sequence* (*cf. § V. Taking Spectra with FLAMINGOS: E. Taking Flats and Wavelength Calibrations).*
9. *Take a long slit spectrum of a telluric absorption star at an airmass at the middle of the dither sequence.* Use a bright star with spectral type G5-6 V.
10. S*ome observers also take a long slit spectrum of an A0 V star.*

E. Taking Flats & Wavelength Calibrations

There are two types of calibrations required for long slit and MOS spectra: wavelength calibration and flat fields. The 4-m guider/rotator above FLAMINGOS provides a set of quartz and arc lamps for these calibrations.

NOTE: The 4-m calibration projection unit was designed for the RC spectrograph, whose field is smaller than 10 arcmin. Therefore, this does not provide uniform coverage of the entire FLAMINGOS field of view, and flats/arcs will be significantly weaker at the ends of the mask or slit. In addition, the quartz optics within the

projector have absorption bands near 2.3 microns which will show up in the flatfield spectra. *Therefore, an alternative approach to obtaining flats is to observe the inside of the dome using the flatfield lights mounted at the end of the telescope.*

Usually only one set of wavelength calibrations is needed per target; alternatively the OH sky lines may be used for wavelength calibration, if they are not saturated.

Flat fields should be taken contemporaneously with the target observations: there may be flexure between the slit and the detector which is dependent on telescope hour angle (HA) and zenith distance (ZD). Additionally, if one tries to take them at a later time it may not be possible to precisely insert the slit and grism in exactly the same way as they were when set up on the target. More than one flat field data set may be required if the observation spans a large enough range of hour angles ($\geqslant$ 1 hour, possibly).

We recommend the following:

- If the target is a bright standard star, then the observation time probably is short and a single set of calibrations, *taken after the target*, should suffice.

- If the target is faint, and the time on source is long, take more than one set of flats at several different hour angles that lie within the same range of hour angles as covered by the science target, but *take them all after finishing the target's observations*. For example, if the science target is taken over the hour angle range from -2:30 and ending at +1:00, then take a set of flats at the final hour angle, then move the telescope back to an hour angle similar to the initial hour angle, and take another set of flats (the telescope does not need to be tracking). Or, if you only have time for one set of flats, consider moving the telescope to the midpoint of the track in hour angle.

The following procedure is used for taking quartz flats with the rotator/guider calibration projector after taking science target spectra. The alignment of the slit, filter and grism should not have been changed from that used for the science target. It should take 5 – 10 minutes to complete.

1. *Have the telescope operator do the following:*
   - Pause guiding. To do so, just hit the OFF button for the guider.
   - Turn down the guide camera gain.
   - Select the Comps mirror position.
   - Select the Dim Quartz lamp at 100% power.
2. *Set filename and exposure time.* Use `config.exposure.pl`.
   - Integration times of `10 - 30 seconds` should suffice for JH-band and HK-band spectroscopy.
   - Take a test exposure (`singleimage.pl`). The counts should be `<25,000 ADU` for wavelengths `< 2.4 microns`.
   - With 30 second itimes, it is possible to do 8 reads, if you can accept the little bit of extra overhead.
3. *Take 5 flats with the lamps on.* Use `more.single.images.pl 5`.
4. *Have the telescope operator turn down the quartz lamp, or turn it off.*
   - Leave the comp mirror in place.
   - With flats at two different illumination levels, they can be differenced to remove the dark current.
5. *Take 5 flats with the lamps off.* Use `more.single.images.pl 5`.
6. *Have the telescope operator turn on the HeNeAr lamp.*
7. *Take 5 wavelength calibration images.* Use `more.single.images.pl 5`.
   - Integration times of ~`60 seconds` should work for JH-band spectroscopy.

- We usually use only sky lines (OH) for wavelength calibration in the HK-band.

If you wish to resume guiding on the science target for additional observations without rechecking the alignment (*this may or may not work*):

1. *Have the telescope operator do the following:*
   - Turn off calibration lamps.
   - Take out the Comps mirror (put it back to the THRU position).
   - Resume guiding. ***N.B.:***
     - When guiding is suspended the guide star may move slightly out of the guide box.
     - Make certain the telescope operator **DOES NOT WARP** the guide box onto the star to resume guiding. Doing so will move the guide box to the star's present location, and the telescope will be guiding at the wrong place, *i.e.*, your target will no longer be optimally aligned on the slit.
     - If the star has moved out of the guide box, the telescope operator should:
       - Leave the OFF button pushed on the GUI.
       - Tweak the telescope pointing with the hand paddle to move the star into the guide box.
       - Once the star is in the box, resume guiding by pushing the LOCK button on the GUI.
     - Once the star is again in the guide box, wait a minute to watch the guide software capture the star's location, and move it back to the guiding center within the guide box.

2. *Take a junk image.*

To obtain dome flats, position the telescope at the HA midpoint of the target observation (as for the quartz flats).

1. *Have the telescope operator do the following:*
   - Turn off telescope tracking and position the telescope at the HA midpoint of the target observation.
   - Turn off dome tracking
   - Manually move the dome so that it completely blocks the telescope aperture
   - Turn on the flatfield projector on the telescope using the Bright lamps at maximum setting
2. *Set filename and exposure time.* Use `config.exposure.pl`.
   - Integration times of `10 - 30 seconds` should suffice for JH-band and HK-band spectroscopy.
   - Take a test exposure (`singleimage.pl`). The counts should be `<25,000 ADU` for wavelengths `< 2.4 microns`.
   - With 30 second itimes, it is possible to do 8 reads, if you can accept the little bit of extra overhead.
3. *Take 5 flats with the lamps on.* Use `more.single.images.pl 5`.
4. *Have the telescope operator turn down the flatfield lamp, or turn it off.*
   - Flats at two different illumination levels can be differenced to remove the dark current.
5. *Take 5 flats with the lamps off.* Use `more.single.images.pl 5`.

VI.Shutting Down at the End of the Night

At the end of a long and (we hope!) productive night of observing, there is a small sequence of things that need to be done. In order, they are:

1. *Move the wheels to their resting positions*. Using the scripts `config.mos.wheel.pl` and `config.filter.grism.decker.wheels.pl` send the MOS wheel to `imaging`, the Decker wheel to `imaging`, the Filter wheel to `J`, and the Grism wheel to `true_dark`.

2. *Take any necessary dark frames*. Now that the grism is in the dark position, you will be able to take dark frames. We recommend 10-20 darks per exposure time. Use the `set.exposuretime.pl`, `set.filename.pl`, and the `more.singleimages.pl` scripts to complete this task.

3. *Fill the MOS Dewar* (as long as no one is changing MOS plates) - use the same procedure as at the beginning of the night.

4. *Begin writing the transferred data to tape or DVD.*

VII.At the End of Your Run

Make certain that you have transferred all of your data to *nutmeg*, or some other Kitt Peak computer, and written it to tape or DVD. Although data from all Kitt Peak telescopes is archived, we still suggest that you make all necessary copies of your data, or back it up on a laptop, *before you leave the mountain.*

Also, please delete your data from *flamingos1a* as you leave.

Finally, please do not close any of the FLAMINGOS windows. Leave them open for the next observer, or for the Kitt Peak Instrument crew, as they will need them open in order to properly shut down FLAMINGOS if they are doing an instrument change after your run.

We hope you have many clear, sleepless nights, and acquire all the data you desired.

VIII.Troubleshooting

1) Problem: The image looks funny. You can see all 32 amplifiers, and the signal level is ~58,000 ADU; the preceeding or following image(s) has 0 counts.

Solution: This is a hardware problem related to electrical noise causing an early readout of the detector. In imaging mode MCE4 reads the array once, and then lets it integrate before reading it again *(cf. Appendix 2: Readout Schematic)*. The final image written to disk is the difference of these two images. This problem occurs when MCE4 spits out the image before making the second read and difference. There is nothing you can do to resolve the problem.

Typically, we get bad reads for about 2-5% of the images taken for exposure times ≤ 60 seconds. If you are getting a much higher failure rate you should call for help

You should be cautious with the image immediately following a bad read frame, because the ADU level in the image is frequently lower than it should be.

Recently we found that if you get more than two zero frames in a row, then the MCE4 array controller needs to be rebooted and reinitialized. See the solution to item `4a` of the troubleshooting guide for how to do this. **N.B.:** the first image taken immediately after rebooting MCE4 also looks like a bad read.

2) Problem: The image looks funny. Various bits of it are scrambled or not in the correct position, or some bits of it are completely black (0 ADU).

Solution: See if the next image looks normal, if it does keep taking data. If the next image is similarly messed up, then the MCE4 array controller needs to be rebooted. See the solution to item `4a` for how to do this.

3) Problem: Excess Background

Possible solutions:

a) Image a very bright star (V ~ 2) at K_s-band, with the telescope way out of focus, say 2000 units lower. You should see a donut with a central obscuration and spider vanes. If it's not circular, then you could have something obscuring the beam---*e.g.*, the dome, the mirror covers, or a mispositioned filter, lyot stop, or Grism wheel.

b) Check that the ion gauge on the Granville-Phillips pressure monitor is off. When left on it casts a large amount of warm illumination on the lower right hand corner of the array.

c) Check that the MOS dewar temperature is lower than 200 K. If the temperature is not between 80 – 95 K, did you forget to fill the dewar with LN_2? What about the camera dewar?

4) Various Problems related to image readout, wheel motion and iocomm communication.

The three daemons started by `initflam.pl` (temperature, motor, and MCE4) work by issuing commands to particular hardware addresses on a networked device called the *perle (*this used to be the *iocomm*, but it was replaced by the *perle*). This device is like a multiplexer. We have three devices (the temperature monitor, the

motor controller, and the MCE4 array controller) which accept commands via serial ports. The *perle* has one serial port connection for each device. Commands from the software daemons running on *flamingos1a* are received by the *perle* via an ethernet connection, and then passed to the correct device.

Troubleshooting several types of problems involves deciding if the problem is intrinsic to the device, or to the communication via the *perle* itself.

a) Problem: The image has not read out. The exposure time counter never appears.

Sometimes the array controller crashes before the image acquisition script issues the `START` command to MCE4. For example, a successfully started image acquistion should show:

```
/usr/local/uf/bin/ufdc -host flmn-4m-1b -port 52008 -acq "start -timeout
9 -cnt 1 -lut /usr/
local/flamingos/flamingos.headers.lut/Flamingos.lut -fits
/usr/local/flamingos/flamingos.hea
ders.lut/Flamingos.fitsheader -file /data0/4mguest/Test/test -index 2"

If it hangs here for more than ~6 seconds, type ufdc -q status in
another flmn-2m-1b window

ufdc> greeting: UFGemMCE4Agent -- accepted client: ufdc@flmn-2m-
1b@2002:350:03:40:49.170980
2002:350:03:40:49.170980
2002:350:03:40:50.440745ufdc@flmn-2m-1b
START

GATIR *Flamingos Beta* 2.00_f.07 >>

>>>>>.....TAKING AN IMAGE OR APPLYING LUT.....
(Exposure time + number of reads = 3 + 1)
Have slept 3 seconds out of an exposure time of 4 seconds
```

If you do not see the `START` command and the exposure time counter above, then MCE4 has crashed. The statement in the output above that saying to type `ufdc -q status` is a red herring, doing so will not change anything.

Solution: Reboot MCE4 and reinitialize it with `initflam.pl`. To reboot MCE4 telnet to *baytech* from *flamingos1a* with userid *mce4pow* and password _____. Type `reboot 1`, and wait for the prompt to return. Then type `logout`. Example output from this procedure follows:

```
4mguest@flmn-4m-1b{2001}telnet baytech
Trying 140.252.53.86...
Connected to baytech.
Escape character is '^]'.

    RPC-3 Telnet Host
    Revision F 4.20a, (C) 1999
    Bay Technical Associates
    Unit ID: flmn-4m-1b

    Enter username>mce4pow
    Enter password>_________
  Option(s) installed:
  True RMS Current
```

```
Internal Temperature

True RMS current:  1.6 Amps
Maximum Detected:  1.7 Amps

Internal Temperature: 18.5 C

Circuit Breaker: On

Selection   Outlet    Outlet   Power
  Number     Name     Number   Status
    1       mce4        4       On

Type "Help" for a list of commands

RPC-3>reboot 1
 (Now it counts down for 10 seconds before applying the power).
..RPC-3>logout
```

Now run `initflam.pl` at the *flamingos1a* prompt. You do not need to close any of the daemons to rerun `initflam.pl` for this problem. At the start, `initflam.pl` will complain that the motor and mce4 daemons are not up and listening, and ask if you want to continue. You do want to continue, as the daemons were working properly before the crash of MCE4. MCE4 must be reinitialized, in order to set the proper clocking of the array. If you were taking a spectrum, you need to reset the bias to `0.75 V`. After it has successfully initialized the EDT frame grabber (where it says "do you see 10 lines of text between a line saying `opening pdv unit 0` and a line saying `done`"), it will ask if you want to continue. You can type `y` at this point.

Next, you need to take two junk frames with short exposure time (*e.g.,* 3 seconds). The first frame after repowering and initializing MCE4 will look like a bad read; however, the second frame should look normal.

b) Problem: The image will not read out. A communication error message appears.

The following error message appears during the integration:

```
UFClientSocket::connect> unable to connect to flmn-4m-1a, port #
52008Connection refused
ufdc> unable to connect to MCE4 command server agent...
```

Solution: The fiber optic serial communications between the *perle* and the MCE4 controller may have been switched off inadvertently. There are two fiber converter units, one below the MCE4 controller on the left-hand rack, the other below the *perle* on the right-hand rack (Figure 2, below). Each has two small toggle switches, which must be set so that the red and green LEDs are OFF. The LEDs are used only for testing that the fiber is working.

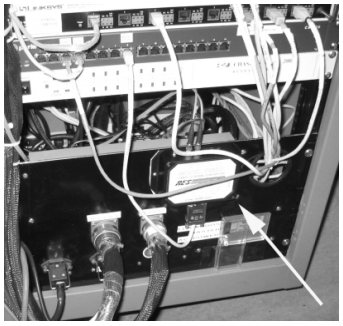


Figure 2. Fiber optic converter boxes below MCE4 (left panel) and below *perle* (right panel)

c) Problem: The image acquisition counts past the exposure time without reading out an image.

Solution: This problem rarely happens anymore. With our previous slower version of *flamingos1a*, it would sometimes take an extra 5 to 10 seconds to finish reordering the pixels, i.e., applying the look up table, or LUT, before it writes the image to disk. In the MCE4 daemon window you sould see string of dots being printed out during the apply lut phase:

```
UFEdtDMA::applyLut>  .  .  .  .  .  .  .  .  .  .
```

You should watch for several seconds to see if this line is present, and that it is printing additional dots. When it finishes, it should also print something similar to:

```
UFEdtDMA::takeAndStore> close mmap file:
/data/4mguest/Test/test.0002.fits
UFEdtDMA::> completed: 1 -- /data0/4mguest/Test/test.0002.fits
ufgtake> acquired frames: 1
UFEdtDMA::takeAndStore> close mmap file:
/data/4mguest/Test/test.0002.fits
UFEdtDMA::> completed: 1 -- /data0/4mguest/Test/test.0002.fits
ufgtake> acquired frames: 1
```

If this never appears, try typing `ufstop.pl -stop -clean` at a *flamingos1a* prompt. Then try taking another image; if that fails see if `ping perle` returns with the message that the *perle* is alive. If the *perle* is alive, try rebooting MCE4 and reinitializing. If that completely fails, call for help.

d) Problem: A large number of error messages are printed out either when trying to move a wheel (e.g., with `config.filter.grism.decker.wheels.pl`), or during the first part of an image acquisition, where it sends commands to MCE4.

Solution: It's possible that the *perle* (formerly, *iocomm*) has crashed, or is very confused. Try `ping perle` from *flamingos1a*; if there is no response, it needs rebooting. Even if there is a response, it may be advisable to reboot it. To do this `telnet baytech`, userid *perlepow* password _____. At the prompt type `reboot 1`, and then type `logout` when the prompt returns (e.g., see the example output in *3a*, above). Now you must close all three daemons (Temperature, Motor, and MCE4) and the record_temperatures window and run `initflam.pl`.

5) Problems when running config.filter.grism.decker.wheels.pl or config.mos.wheel.pl. The script ends by

saying that the time for the wheel's motion to complete has expired.

The default algorithm for motion of the wheels is that they first go to the home position, tell the controller to zero the position, and then move to the demanded position. We refer to this as a *home-type* of *limit*, or *limit switch*. We usually run the MOS wheel in an alternative mode refered to as a *home-type* of *near-home*. In this mode the wheel moves from the present position back to somewhere close to home, and then to the demanded position.

There are two modes of failure for each wheel.

(1) The limit switch fails to engage. If the wheel operates with a limit-switch home type, then the wheel can spin endlessly, and the perl script will just give up after some time limit. If you can stop the wheel and determine the location of the mechanism, it is possible to recover from such a failure and then use the *near-home* motion algorithm for the wheel.

(2) The wheel binds, and a grinding noise is audible if you stand next to the dewar. If this happens there usually is no quick recovery after you have stopped the motor.

Solutions:

A) First, you must stop the wheel that is either spinning endlessly, or is jammed.

1. Type `ctrl-Z`, type `jobs, kill -9 %<jobnumber>` if the perl script has not yet finished and you already know that there is a problem.
2. Type `ufmotor -host flmn-4m-1a -port 52004`
   a) At the motor prompt, type `<motor_name>@`, where `<motor_name>` is one of letters *a, b, c*, *d*, or *e*, where motor *a* = *decker*, *b* = *mos*, *c* = *filter*, *d* = *lyot*, and *e* = *grism*. This should do a *soft-stop* of the motor.
   b) Type `exit` to quit *ufmotor*.
3. Type `turn.off.motor.hold.current.pl`

If this does not stop the motion of the wheel (e.g., you can hear it spinning, or grinding), the last recourse is to turn off the motor controller itself. ***Note: any wheels that use near-home type and are not at home will be lost when the motor controller is powered up again. You should call for assistance if this happens.*** To do cycle the power on the controller, `telnet baytech` as `motorpow`, password _____, and then `reboot 1`, and `logout` to exit.

B) If the failure was of the limit switch, you need to recenter the mechanism in question, and redetermine the home point. The best way to do this is to image a very bright star with the telescope out of focus by about `3000` units. The wheel probably is not well centered, so use one of the tweak scripts to adjust it (there are special engineering tweak scripts, in addtion to the ones for the decker and MOS wheels). Then step the wheel by discrete positions, and measure the background. With some help you should be able to determine where you are, and use the `ufmotor` command to rezero everything.

IX.Contacts & Further Information

1. Dick Joyce, Ron Probst, and/or Nick Raines will help new observers during their first night of observing with FLAMINGOS at the 4-m. If simple questions arise during the run, please address them first to Dick or Ron, and then to Nick. Their contact information is listed below.

   Richard Elston, University of Florida, FLAMINGOS PI
   office: 352-392-2052
   elston@astro.ufl.edu

   Nick Raines, University of Florida, FLAMINGOS support scientist
   office 352-392-2052, ext. 244
   home: 352-381-9069
   raines@astro.ufl.edu

   Dick Joyce, NOAO Friend of FLAMINGOS
   office: 520-318-8323
   home: 533 (from mountain)
   rjoyce@noao.edu

   Ron Probst, NOAO Friend of FLAMINGOS
   office: 520-318-8268
   home: 521 (from mountain)
   rprobst@noao.edu

2. Updates to this manual and other manuals, and more information, may be found on the web:

Kitt Peak/NOAO web site	www.kpno.noao.edu/manuals/flmn
University of Florida	www.flamingos.astro.ufl.edu/index.html
	www.flamingos.astro.ufl.edu/Manuals/
Richard Elston's web page	www.astro.ufl.edu/~elston/flamingos/home_frame_set.html

3. In the event of a power outage for which the mountain does not switch to generator, please contact the mountain staff about properly shutting down the FLAMINGOS computers (*flamingos1a & flamingos1b).* There is a shutdown manual available off of the Manuals web page, but the procedure requires someone with root access (*e.g.* the mountain staff, or anyone on the list above).

X.Acknowledgements & Other Bits

This version of the manual is substantially more complete from previous versions. Information has been incorporated from previous versions written by Katherine Wu, and Richard Elston and Elizabeth Lada. Helpful suggestions, comments and questions came from (in no particular order): Joanna Levine, Michael Ledlow, Jay Elias, Ron Probst, Dick Joyce, Mark Dickinson, Peter Eisenhardt, and Dan Stern.

Written in `StarOffice 6.0`, a nice program, but with a buggy Postscript driver. To generate a good Postscript version of this document: (1) `print to file`, (2) run `ps2pdf12`, *Ver. 6.52* to convert it to `PDF`, (3) finally run `xpdf`, *Ver. 2.33* to generate sane Postscript that actually will print.

Appendix 1: FLAMINGOS Command Listing and Partial Description of Function

A. Basic Instrument Configuration Commands

`config.exposure.pl`	Sets object, filebase, orig_dir, exp_time.
`config.filter.grism.decker.wheels.pl`	Setup and move Filter, Grism and Decker wheels.
`config.mos.wheel.pl`	Setup and move the MOS wheel.
`initflam.pl`	Starts daemons and setup MCE4 array controller.
`set.bias.pl`	Imaging use bias = 1.0 V; Spectroscopy use bias = 0.75 V.
`set.exposuretime.pl`	Exposure time is in integer seconds; 2 seconds is the shortest.
`set.filename.pl`	Set image's rootname and directory.

B. Basic Imaging Configuration and Acquistion Commands

`config.dither.kpno.pl`	Select dither pattern and number of repeats.
`dither.source.kpno.pl`	At present, only dithers on source in a square grid.
`fast.singleimage.pl`	Automatically take a 1500 `mS` exposure time image.
`more.singleimages.pl #`	Takes # of images with parameters set by config.exposure.pl.
`singleimage.pl`	Automatically take an image with present integration parameters.
`config.dither.strip.kpno.pl`	Used to setup a running strip of square dithered images.
`dither.strip.clear.kpno.pl`	Takes a running strip of square dithered images.

C. Basic Spectroscopy (MOS and Long Slit) Configuration and Acquisition Commands

`config.mos.dither.kp4m.pl`	Setup the spectroscopy ABBA parameters, including position angle.
`dither.mos.kp4m.pl`	Take the spectrosopy ABBA data
`set.new.mos.plate.names.pl`	Use when loading new MOS plates so their names are in the header.

D. Advanced Imaging and Spectroscopy Commands

`config.chippa.kp4m.pl`	For setting the chip PA on the sky.
`config.slit.chip.pa.kp4m.pl`	For setting the PA of the slit wrt the chip.

E. Telescope Information and Motion Controller

`clear.offsets.kpno.pl`	Absorb present offsets into the present position; offsets now 0, 0.
`offset.kpno.pl`	Absolute offset wrt pointing center of telescope.
`relative.offset.kpno.pl`	Offset telescope wrt the present offsets.
`wcsinfo.pl`	Request the present TCS information.

F. Resetting the Array Controller (MCE4), the Motor Controller, and the Iocomm

From *flamingos1a*:

1. `telnet baytech` userid: `mce4pow, motorpow, or perlepow`
   password: _____
   (For telnet from a Kitt Peak machine, the baytech's name is *flmn-4m-p*).
2. `reboot 1`
3. `logout`
4. If you rebooted the *perle*, close all daemons (the TEMPS, MOTOR, and MCE4 xterm windows), otherwise leave them open.
5. `initflam.pl`

G. Data Transfer and Data Compressing, Data Taping & DVD Burning

Data are written to disk on *flamingos1a* automatically. At the start of every night you should run a special script (see below) which will automatically copy the data to *nutmeg*. Once the data start arriving on *nutmeg*, and before writing data to tape or to a DVD, we recommend that you compress the data using gzip (we usually compress the data as a step separate from the tar command if we are writing tapes).

If you change the file prefix frequently throughout the night, consider incrementally gzipping the transferred data; gzip is usually pretty slow, so this will give you more time in the afternoon for archiving the data. *Whatever you do, do not gzip the data on flamingos1a as you are taking data, because it will slow down data acquisition.*

Instructions for moving data from flamingos1a to nutmeg:

- Run *Start.autocopy.4m.nutmeg.sh* at the start of the night in order to background copy the data to *nutmeg*.

Common commands used for writing tapes with the DDS4 tape drive on nutmeg:

- `mt -f /dev/nst0 status`
- `mt -f /dev/nst0 fsf #`
- `mt -f /dev/nst0 rewind`
- `mt -f /dev/nst0 offline`
- `tar -cvf /dev/nst0 night1.dir/`

Burning DVDs:

1. From a *nutmeg* terminal, type `dvdrecord -scanbus`. Examination of the output should show a Pioneer DVD-RW burner on dev=2,0,0.
2. Use `mkisofs -R -J -o night.iso night/` to make an iso file (see the appendis in the manual on burning DVDs). **Note:** a DVD will hold ~ 4.3 GB of data, which is ~265 FLAMINGOS images.
3. Use `dvdrecord -dao dev=2,0,0 night.iso` to burn the DVD.
4. When it finishes, use `mount /mnt/dvdrom` and `ls /mnt dvdrom` to inspect the files on the DVD. When complete, `cd` out of `/mnt/dvdrom` and `umount /mnt/dvdrom` and then `eject /mnt/dvdrom` to eject the DVD.

H. Instrument Engineering Commands

`center.of.rotation.pl`	Determine the center of rotation from 3 points.
`config.location.pl`	Copies the correct Flamingos.fitsheader for a telescope.
`engineering.config.home.type.wheels.pl`	Sets Limit Switch or Near Home wheel motion.
`engineering.config.mst.pl`	Sets milliseconds *vs.* seconds timer usage.
`engineering.config.output.pl`	Various settings (unlock file, talk to TCS, png image, etc.).
`engineering.ct10.singleimage.pl`	Output the first read of a CDS read.
`engineering.ct12.singleimage.pl`	Output the first set in a multiple read.
`engineering.ct17.pl`	?
`engineering.ct40.takecnt.pl`	?
`engineering.more.ct10.pl`	Takes multiple CT 10 frames.
`engineering.more.ct17.pl`	Takes multiple CT 17 frames.
`engineering.set.lyot.wheel.pl`	Moves Lyot wheel for each telescope.
`engineering.soft.stop.mos.wheel.pl`	Sends and escape character to the MOS wheel controller.
`engineering.tweak.filter.wheel.pl`	Allows adjustments to the filter wheel position.
`engineering.tweak.grism.wheel.pl`	Allows adjustments to the grism wheel position.
`engineering.tweak.lyot.wheel.pl`	Allows adjustments to the lyot wheel position.
`readFITheader.pl -f /usr/local/flamingos.headers.lut/Flamingos.fitsheader`	Prints out the present fitsheader template file for the next image.
`turn.off.motor.hold.current.pl`	Sends command to filter, lyot and grism wheel controllers.
`tweak.decker.pl delta_angle`	Allows adjustments to the decker wheel position.
`tweak.mos.pl delta_angle`	Allows adjustments to the MOS wheel position.
`ufidle.pl`	Sets MCE4 in continuous resetting mode on the array.
`ufstop.pl -clean`	Sets various semaphores in /var/tmp/
`ufstop.pl -stop`	Stops the present integration.

Appendix 2: Readout Schematic

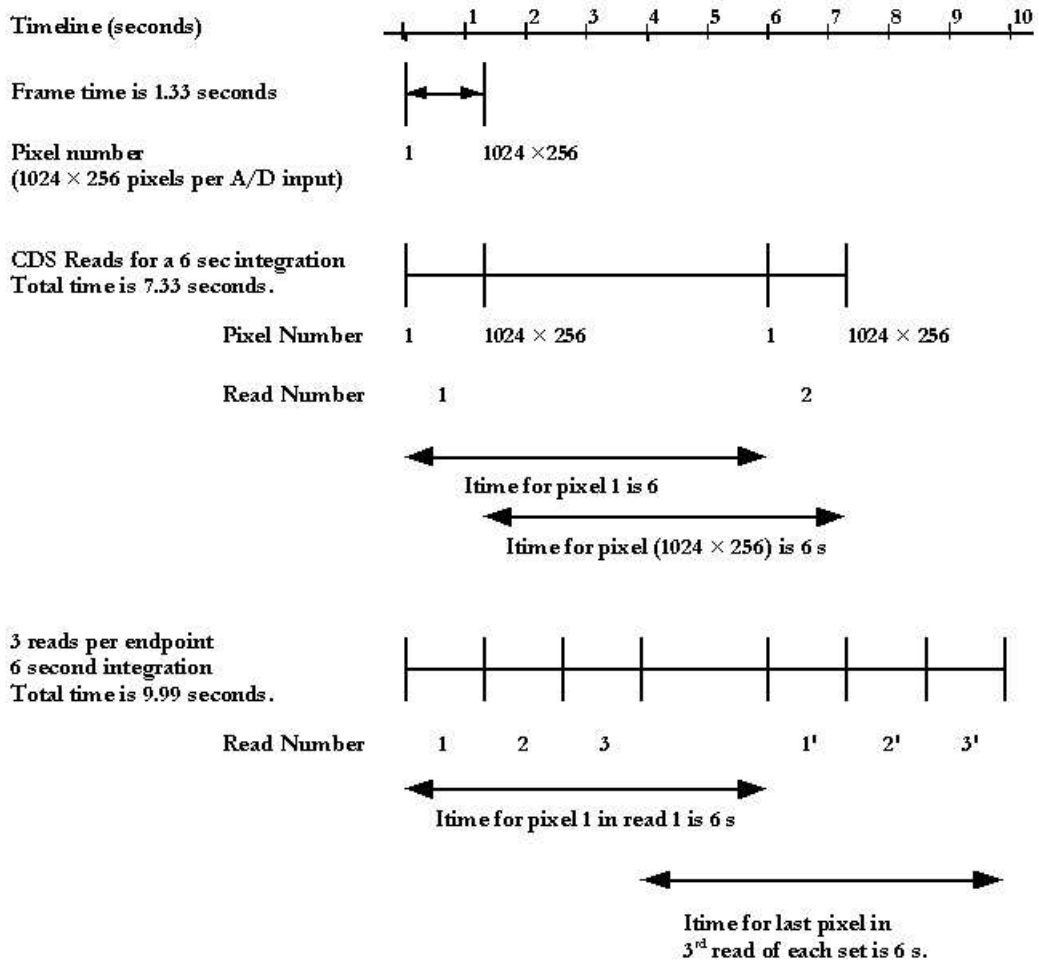


Figure 3 Array Readout Timing. All 4 quadrants of the array are read out simultaneously; within one quadrant all 8 amplifiers are read out, with pairs of amplifiers multiplexed down into one A/D input. Thus in a frame time of 1.33 seconds 1024 × 256 pixels are read out. The image delivered by MCE4 for a CDS frame is the difference image from two nondestructive reads of the array; the timing for a CDS frame with integration time of 6 seconds is shown. Note that the total time to take this frame is 6 + 1.33 seconds, but the net integration time for all pixels is 6 seconds. The case for 3 multiple reads is also shown. For a 6 second integration this takes ~10 seconds. MCE4 delivers the difference image of the sum of each set of 3 reads. Thus the final image with multiple reads is a *coadded* image; the pixel values will be 3 times larger than that obtained with a CDS read.

Appendix 3: XBOX Default Parameter List for Instrument at PA = 90 degrees

```
PACKAGE = ucsclris
TASK = xbox

image     =  target.0001   image
input     =  box1     input file (box locations)
(stars    =           ) file of star centroids, using 'a' key in imexam
(nxbox    =  50       ) nx of extraction box
(nybox    =  50       ) ny of extraction box
(xsz      =  30.      ) x box length (pixels @ .15mm/pix)
(ysz      =  30.      ) y box height (pixels @ .15mm/pix)
(fwhm     =  4.       ) star FWHM in x (pixels @ .21''/pix)
tel       =  4m       Telescope - 2m,4m,MMT or GemS
(rotdir   =  -1       ) Enter rotator direction (1,-1)
rot_2m    =  90.      Enter 2m rotation offset
xrot_2m   =   1162.   Enter 2m center of rotation x
yrot_2m   =  -1868.   Enter 2m center of rotation y
invert2m  =  no       Enter if 2m field is flipped (yes/no)
rot_4m    =  -90.     Enter 4m rotation offset
xrot_4m   =   1162.   Enter 4m center of rotation x
yrot_4m   =  -1868.   Enter 4m center of rotation y
invert4m  =  yes      Enter if 4m field is flipped (yes/no)
MMT_rot   =  90.      Enter MMT rotation offset
MMT_xrot  =  1024.    Enter MMT center of rotation x
MMT_yrot  =  1000.    Enter MMT center of rotation y
MMT_inve  =  yes      Enter if MMT field is flipped (yes/no)
GemS_rot  =  0.       Enter Gemini South rotation offset
GemS_xro  =  1009.    Enter Gemini South center of rotation x
GemS_yro  =  989.     Enter Gemini South center of rotation y
GemS_inv  =  no       Enter if Gemini South field is flipped (yes/no)
(xoff     =  0.       ) add'n. x shift to apply (pix)
(yoff     =  0.       ) add'n. y shift to apply (pix)
(def_ref  =  0.2      ) default error estimate
(def_err  =  0.2      ) default error estimate
(niter    =  6        ) number of iterations in fit
(box_siz  =  0.5      ) box half-len (usually acceptable resid)
new_x_fw  =  4.       [Enter new x FWHM]
new_y_fw  =  4.       [Enter new y FWHM]
vmag      =  100.     [magnification factor]
wt        =  1.       [weight]
(coord    =  )        graphics cursor input
(mode     =  ql       )
```

Appendix 4: Additional Notes on MOS Plates

An example MOS plate for use at the 4-m is shown adjacent, in Figure 4. It is approximately full size (~105 mm in length).

The sizes of the slits and alignment boxes are the same size in pixels for both telescopes.

The slitlets are 3 pixels (0.9" at the 4-m) wide, with a minimum length of approximately 30 to 40 pixels (9" to 12" at the 4-m).

The alignment boxes are 25 to 30 pixels (7.5" to 9" at the 4-m) on a side.

We usually try to find guide stars with K magnitudes in the range 11–13.

Figure 4—Example MOSplate.

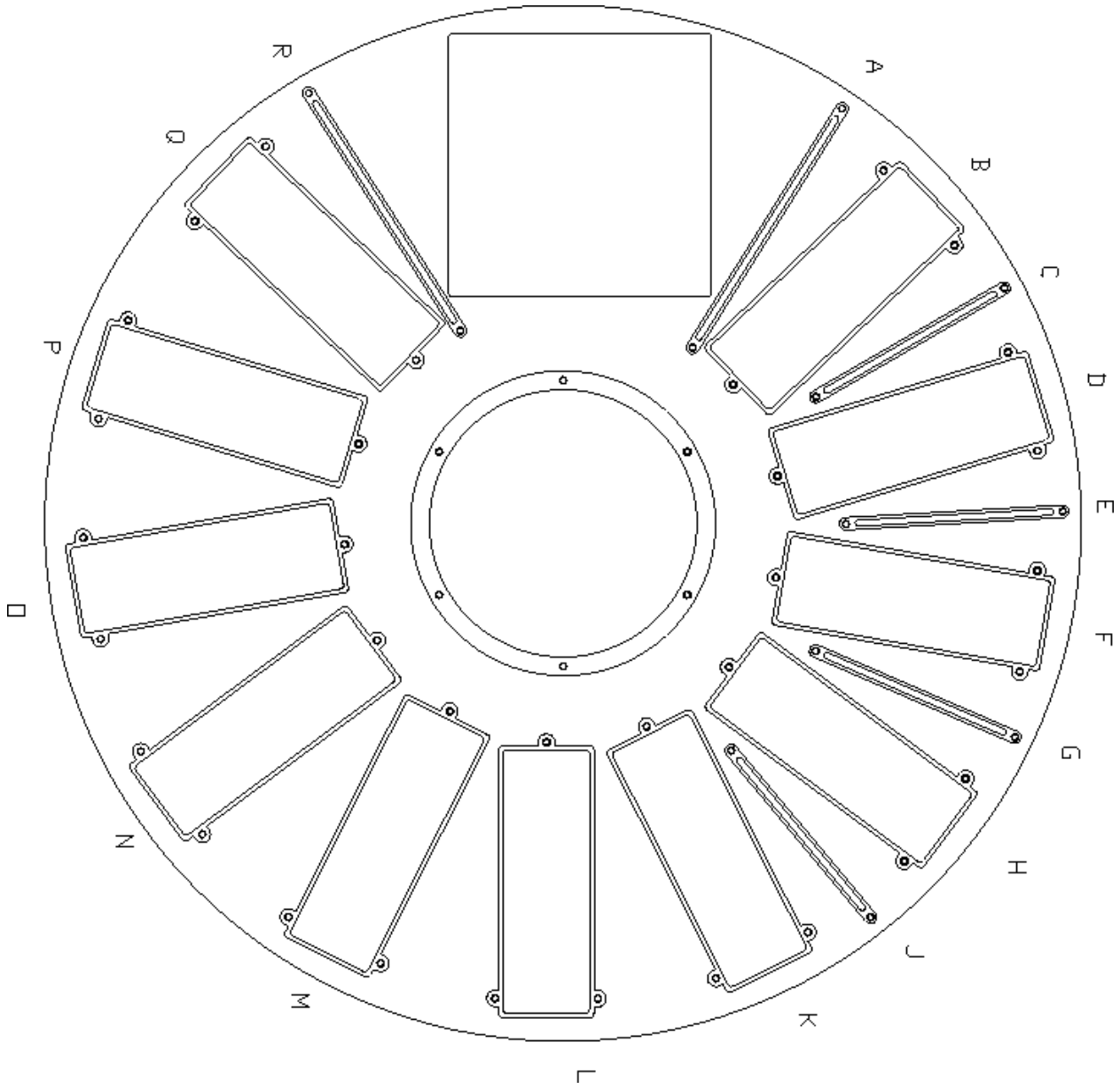
The view of the MOS wheel, from the side that will be seen when loading is presented on the next page. Copy or download and print it (http://flamingos.astro.ufl.edu/Manuals/), and then annotate it as you load the plates.

Critical annotation items include (see Figure 3):

- *Plate name or ID*
- *Rotator Position Angle for proper plate orientation on the sky*
- *Slit Width, in pixels*
- *Compass, with sky parity showing the orientation of North and East*

After the wheel is back in the MOS dewar, and the dewar is on the pump, run the script set.new.mos.plate.names.pl, so that the plate name makes it into the FITS header when the plate is selected.

Appendix 4: Additional Notes on MOS Plates: ***A Figure of the MOS Wheel, Useful When Loading Plates***



MOS Position	*PA*	*Name*	*MOS Position*	*PA*	*Name*
B	_____	_____	*M*	_____	_____
D	_____	_____	*N*	_____	_____
F	_____	_____	*O*	_____	_____
H	_____	_____	*P*	_____	_____
K	_____	_____	*Q*	_____	_____
L	_____	_____			

Telescope: _____
Date Loaded: _____
Observing Program: _____